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JANUARY, 1946

The Radio Amateurs' Journal

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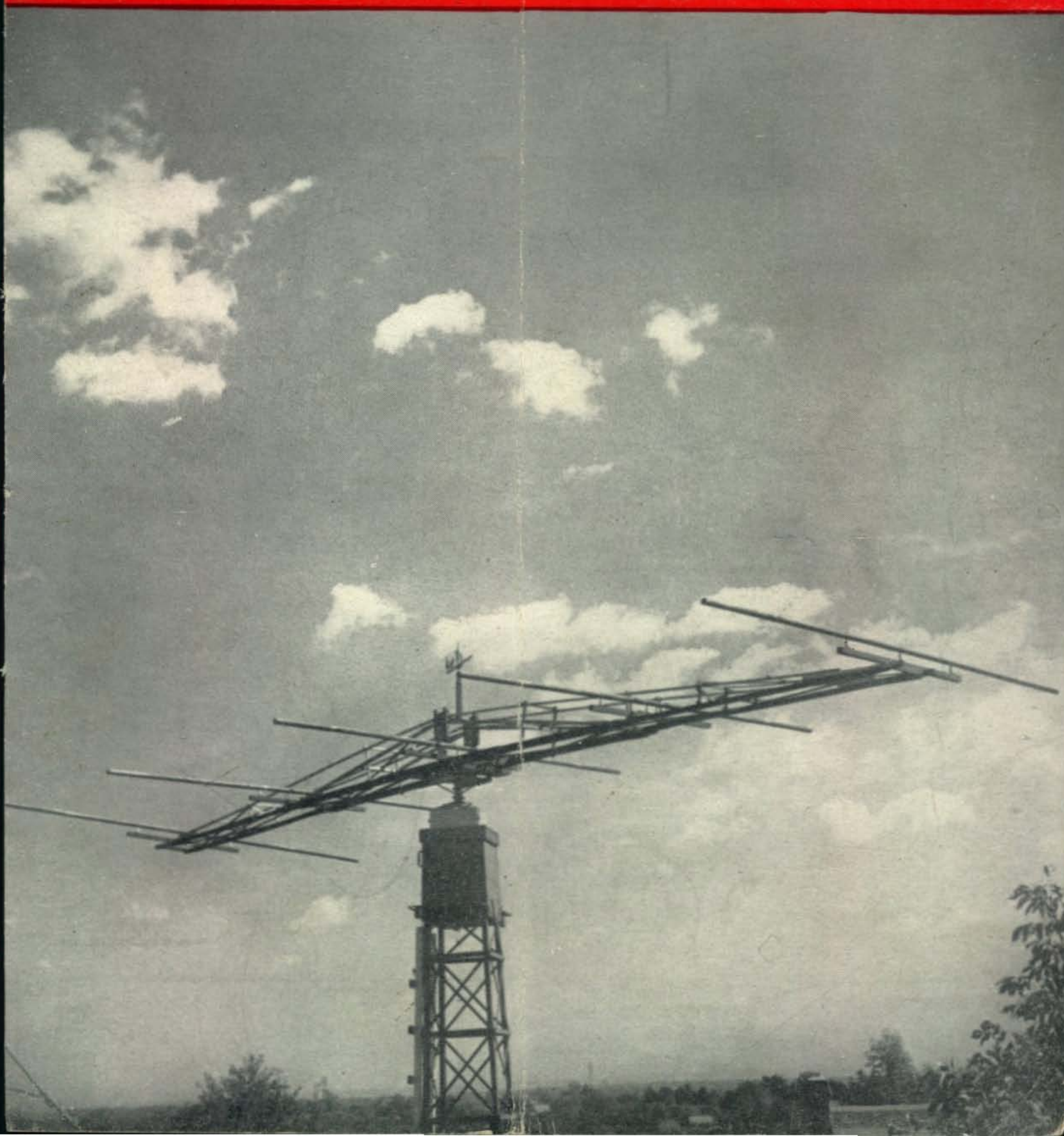

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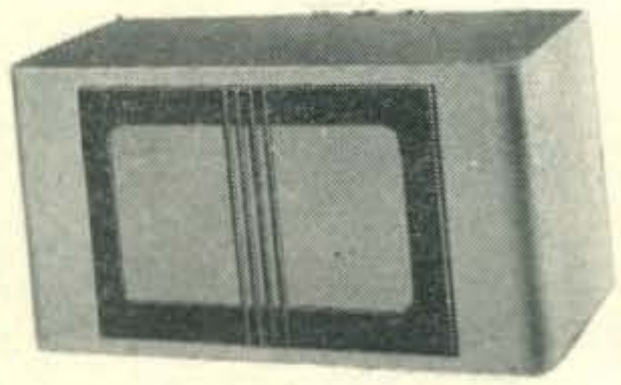

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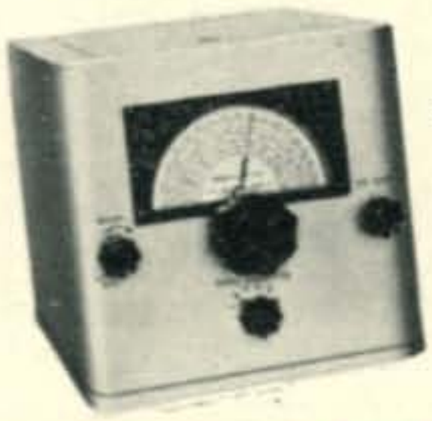

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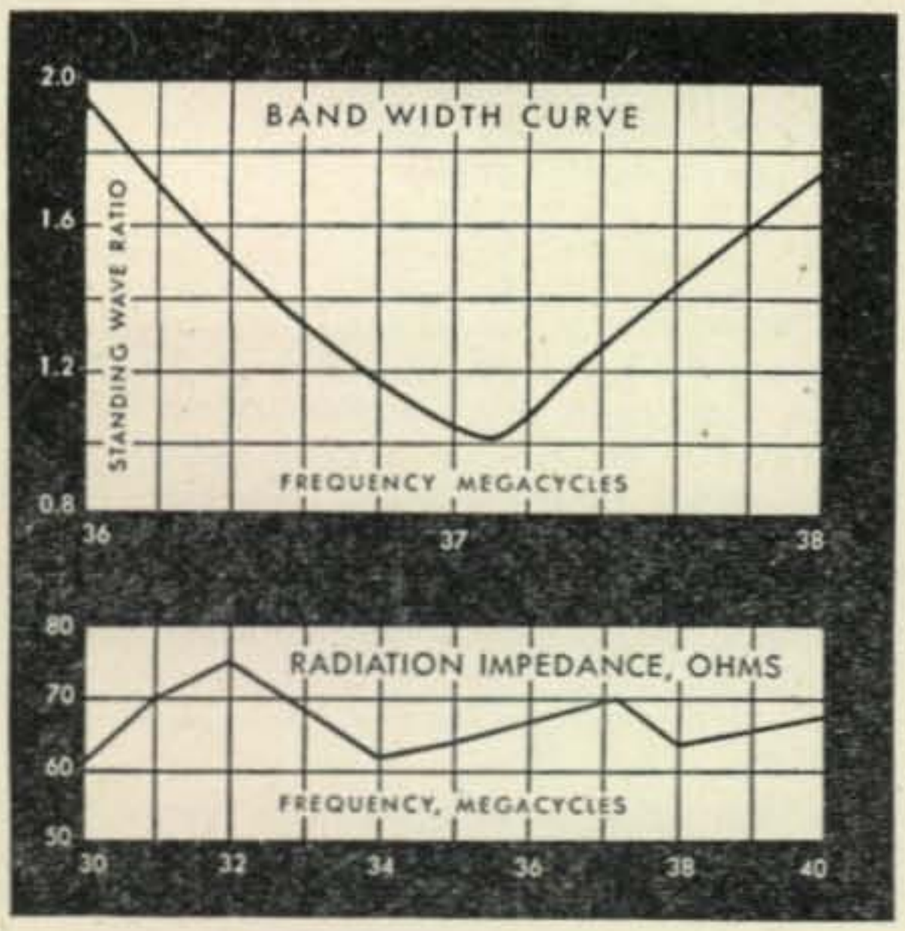

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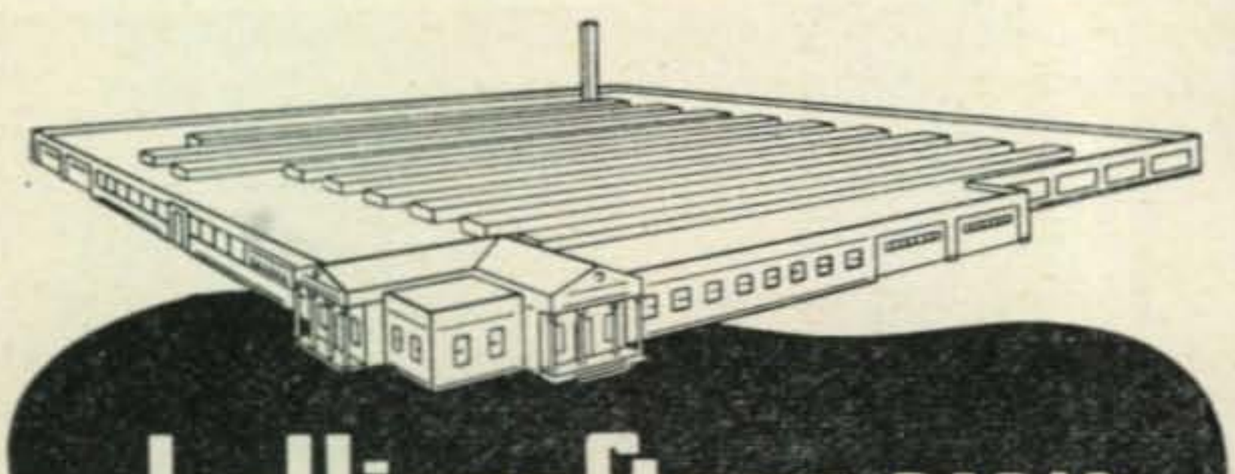

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The Radio Amateurs' Journal

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VOL. 2, No. 1 JANUARY, 1946

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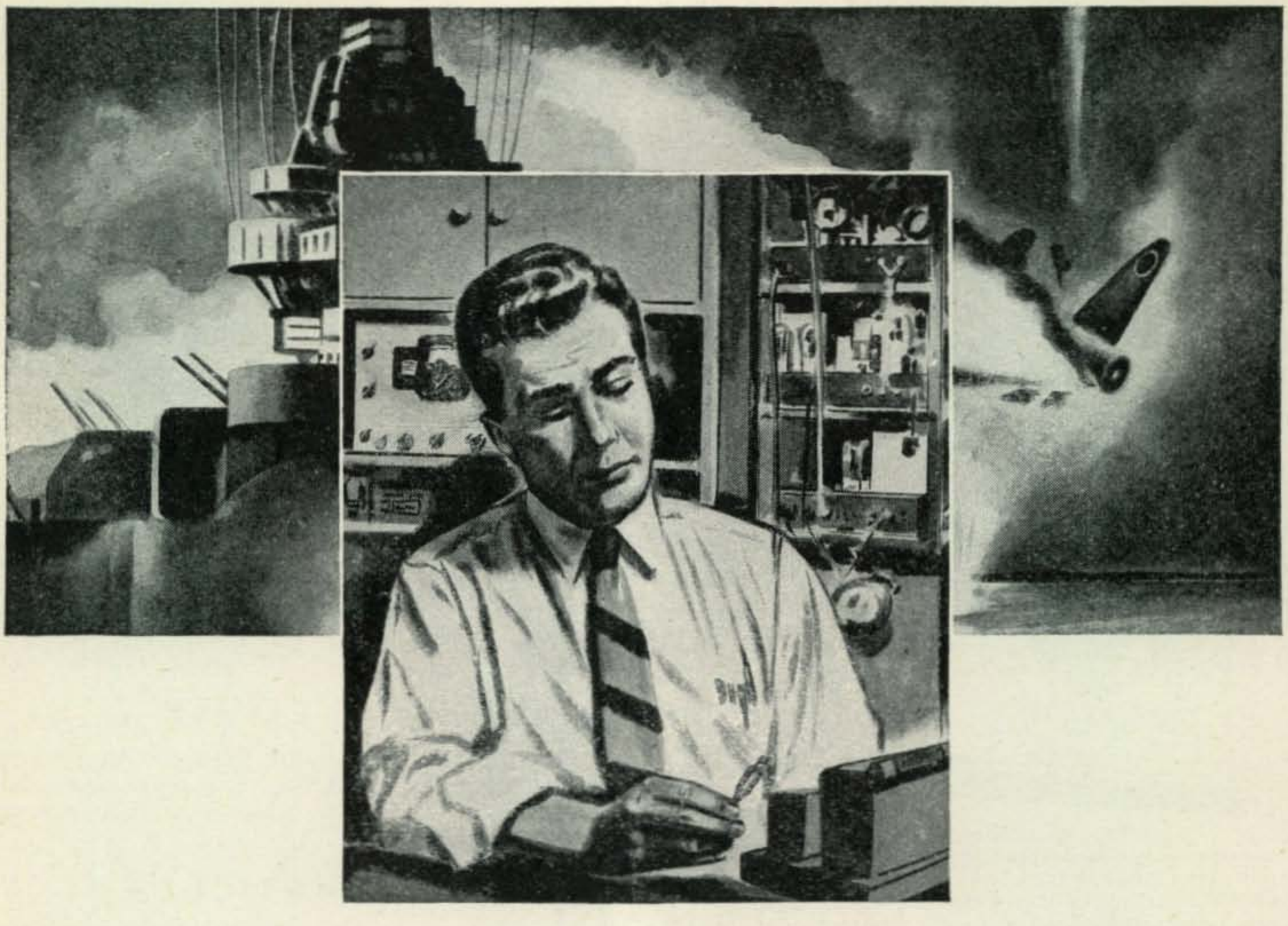
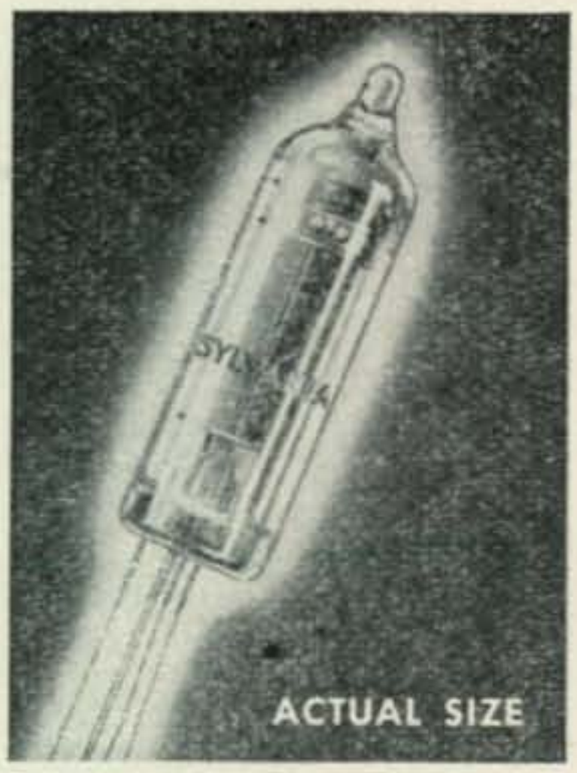


Out of the SMOKE—into your SET!



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ZERO BIAS

CQ HAS RECEIVED many letters protesting the FCC approval of the new call-letter assignment system which would change the calls of several thousand amateur stations. Most of these letters have been vigorous in their denunciation of the approved scheme, and suggest that CQ take a militant attitude in bringing pressure against the idea.

To summarize briefly, the new arrangement will eliminate split-state calls (such as 2's and 8's in New York State), and shift other calls from congested to less crowded areas to even up call-letter distribution. Also, to provide for the estimated increase of amateur activity within the next decade, the archaic and altogether arbitrary division of the country into nine call areas has been revised with the addition of a tenth or ZERO district, and the prefix K will be employed in continental U.S.A. in equality with the familiar prefix W (which alone doubles the possible number of call combinations). Call number allocations in numerical order of call areas are as follows: *1*—New England. *2*—New York and New Jersey. *3*—Pennsylvania, Delaware, Maryland and the District of Columbia. *4*—Virginia, North and South Carolina, Georgia, Florida, Alabama, Tennessee, Kentucky, Puerto Rico and the Virgin Islands. *5*—Mississippi, Louisiana, Arkansas, Oklahoma, Texas and New Mexico. *6*—California, Hawaii and the Pacific possessions except those included in Area *7*. *7*—Oregon, Washington, Idaho, Montana, Wyoming, Arizona, Nevada, Utah, Alaska and adjacent islands *8*—Michigan, Ohio and West Virginia. *9*—Wisconsin, Illinois and Indiana. *ZERO*—Colorado, Nebraska, North and South Dakota, Kansas, Minnesota, Iowa and Missouri.

CQ has no intention of campaigning against this arrangement for many reasons. It is as good and simple a system as any other we have seen proposed and better than most of them. Protests against it have necessarily been prejudiced, emanating from the small minority of amateurs whose calls would be changed. While we appreciate the sincerity of these objections and the pride an old timer takes in a call he has brass-pounded since the two-letter days after the first World War, this phase of the situation is not too serious. Relatively few of such calls will be effected, and where reassignment is in order, the FCC promises to return the same call *letters* in the new district if the problem of duplication does not exist. Pet automobile licenses, telephone numbers and street addresses have been changed without drastically altering one's course of living. The writer, himself, lost a pioneer two-letter call when he moved to another district—and survived the metamorphosis.

Also, some such changes were inevitable, as the Federal Communications Commission was adamant on the elimination of split-state calls. The old system of assigning amateur call letters was based on nine call areas coinciding with nine inspection districts long-since abandoned. These arbitrary call-letter boundaries, cutting through a number of states, gave rise to confusion and delay in processing station and operator license applications. With this revision definitely in order, a complete new set-up, with planning for the future, was the logical procedure. This has been accomplished, we feel, with a minimum amount of dislocation. The newcomer, of course, will never know the difference. And many old timers, who perhaps wondered if World War II might not provide international and commercial interests with an opportunity for putting a permanent quietus on amateur radio, will philosophize that it is better to be on the air with a new call than forever silent. A rose under any other name will smell as sweet.

There is no genuflexion in CQ's acceptance of the new system. Frankly, we feel that the working out of the new arrangement exhibits a healthy interest in amateur radio on the part of the FCC and official Washington—an interest that guarantees the perpetuity of amateur radio in this country and the backing up of our rights and privileges in international conferences.

But even were we less favorably inclined toward the new set-up, we should hesitate to make an issue of the matter. Regardless of personal attitudes, the situation is in no way vital. Thus we feel that amateurdom stands to benefit by cooperating wholeheartedly with the Commission on this question of call-letter re-allocation—strengthening our position and holding our fire for something more important that the future may possibly bring forth.

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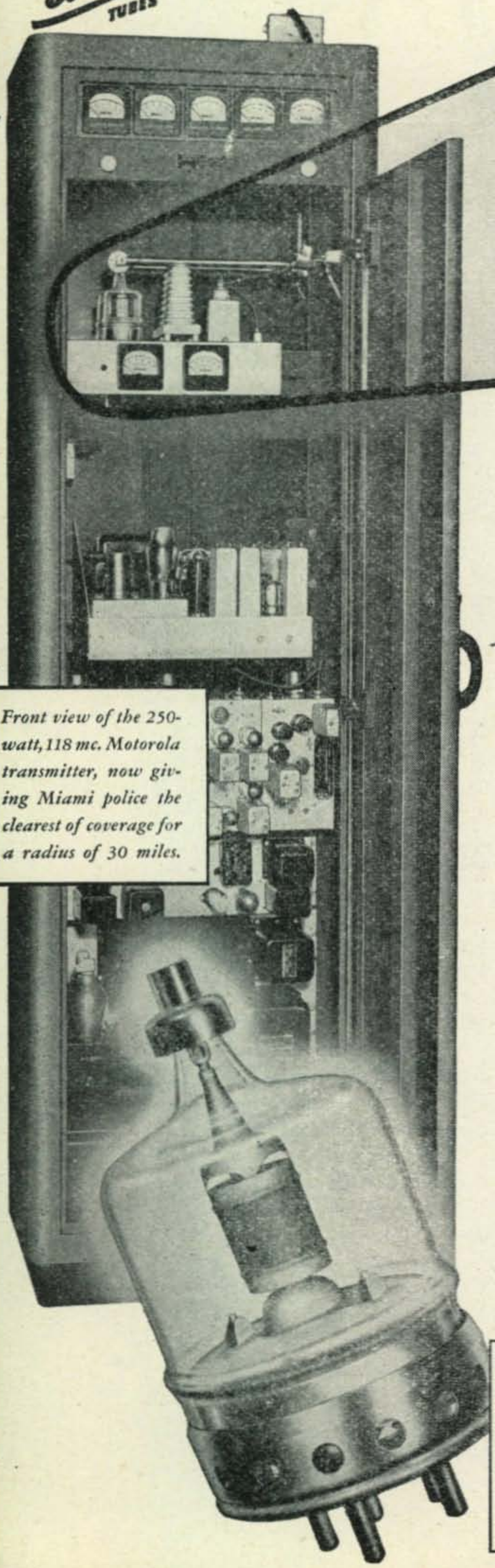
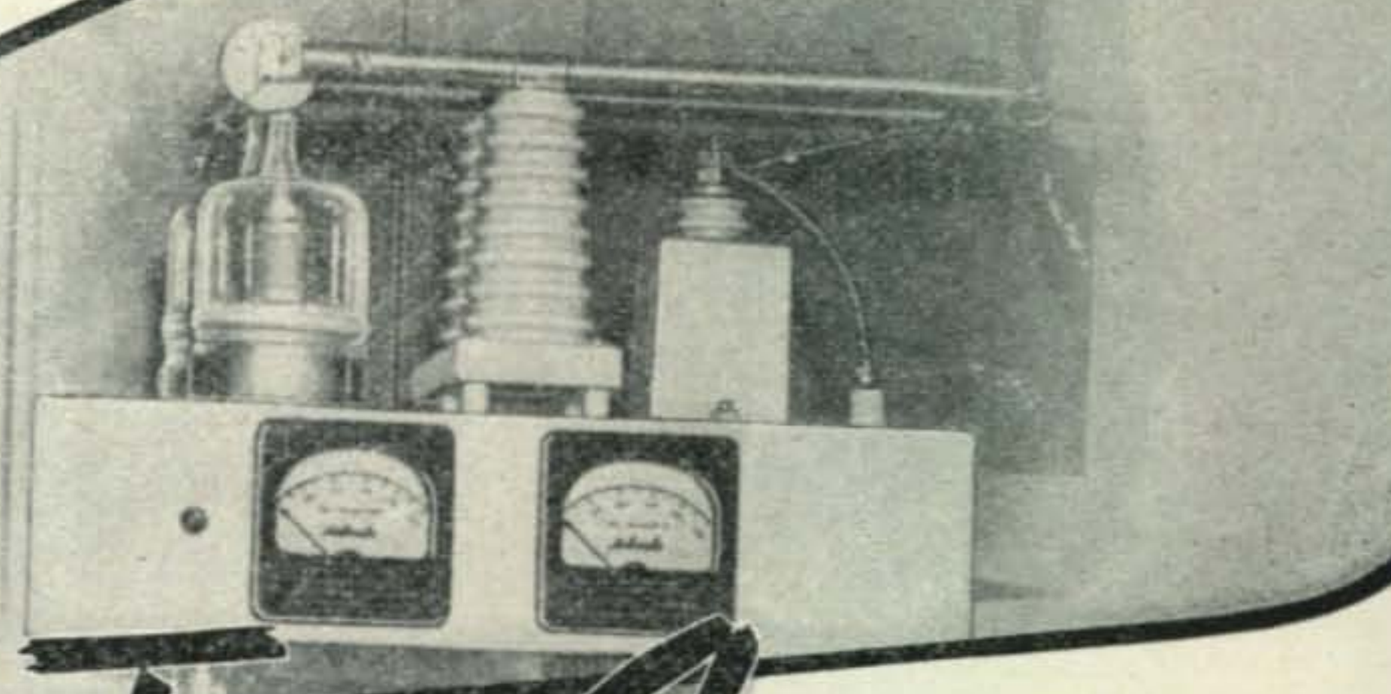


Front view of the 250-watt, 118 mc. Motorola transmitter, now giving Miami police the clearest of coverage for a radius of 30 miles.



Top Spot

IN FM POLICE SYSTEMS

EIMAC TETRODE 4-125A

Top honors to Galvin Manufacturing Corporation for building it, and a salute to the police and fire departments of Miami, Florida, for putting it to work in spite of the skeptics! It's the first two-way police radiotelephone system in the United States on frequencies *above 100 mc.* Twenty-four hours a day, 12 patrol cars in Miami's busy area tune in on signals as solid as a dinner-table conversation from this Motorola 250 watt, 118 mc. FM transmitter.

From the earliest experimental stages of FM broadcasting, Eimac tubes have been lending a hand. Naturally, there are Eimac 4-125A tetrodes (pictured above) in the vital power output stage of Galvin's new Motorola success. Eimac 4-125A's were a logical choice for this transmitter because of their superlative high frequency performance capabilities and their low driving power requirements.

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Current . . 6.2 amperes

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Transconductance (i_b = 50 ma., E_b = 2500 v., E_{c2} = 400 v.) . 2450 umhos

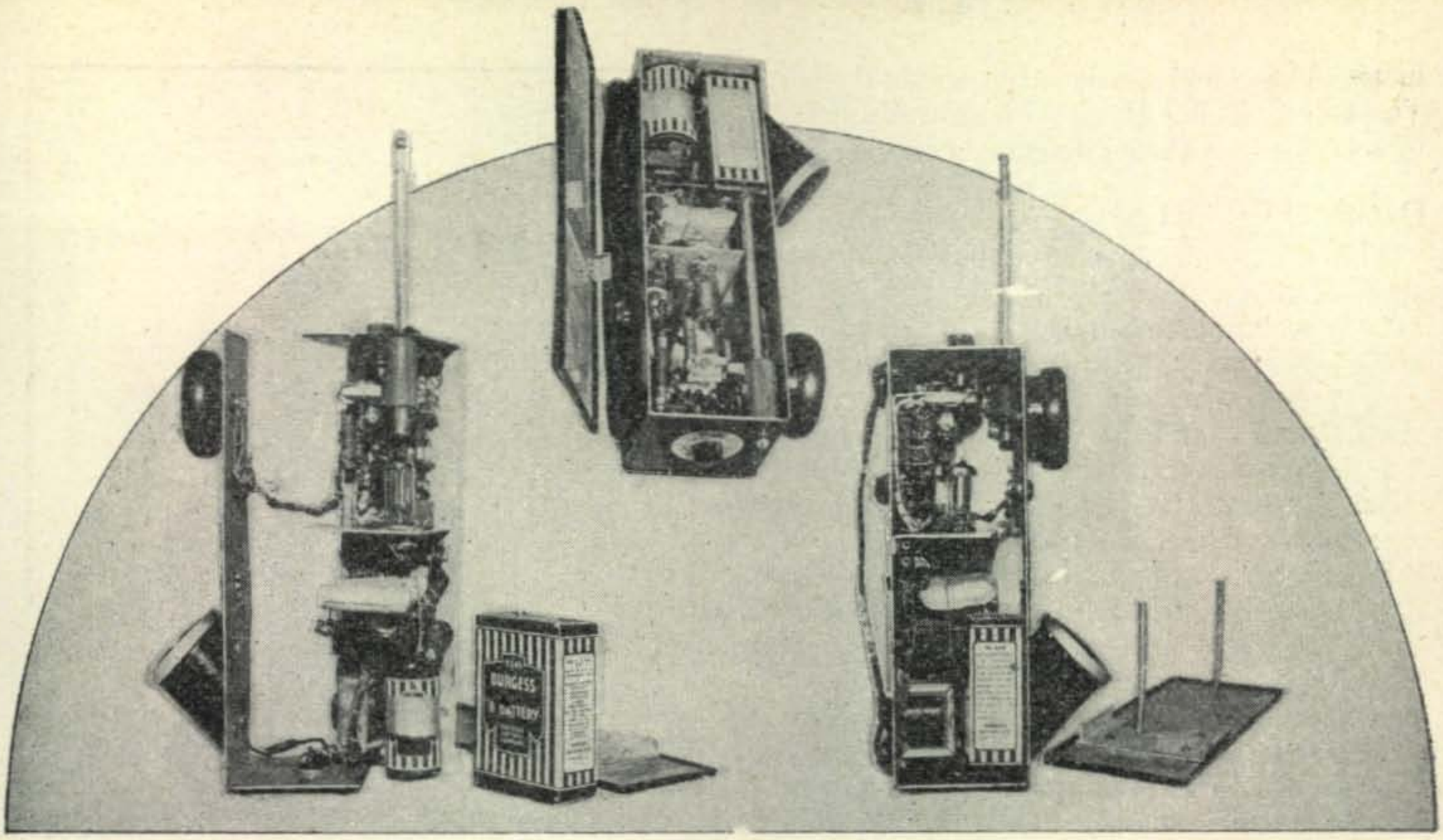


Fig. 1. (left) Showing the placement of parts. The antenna is collapsed in this photo. Fig. 2. (center) The acorn tube and tuning capacitor are mounted at the right, with the audio section center and batteries to the left. Fig. 3. (right) The cover to the right of the unit shows the two tie-rods which hold the cabinet together

HANDY TALKING ON THE 144-MC BAND

WILLIAM H. VOGEL, JR., W2MYE

A PRACTICAL TWO-WAY UNIT THAT WEIGHS LESS THAN FOUR POUNDS WITH BATTERIES

THIS ARTICLE DESCRIBES a compact, light, but dependable radio-telephone transmitter-receiver for operation in the amateur frequency range of 144-148 megacycles. This equipment, however, can easily be revised to operate on higher amateur and civilian radiocommunication frequencies.

The first steps in the construction of the Handie Talkie are the building of the cabinet, the microphone mount and the antenna insulator. These parts are not difficult to make and the sketches with dimensions are self-explanatory. Photographs *Figs. 1, 2* and *3* show the general placement of the parts in the cabinet. The modified variable capacitor is mounted in the top of the cabinet and the acorn tube socket is then situated so that the plate and grid terminals of the socket are closely juxtapositioned to the condenser. The 4PDT rotary switch is mounted about three inches down from the variable capacitor. The placement of the rest of the parts is not too critical. The audio tube is mounted on a small L-shaped piece of 18-gauge aluminum. The microphone and audio (transceiver) transformer are located underneath the DPDT slide-type switch. The small a.c.-d.c. choke is mounted just below and at right angles to the transceiver transformer. The 1½-volt flashlight battery for the filaments is mounted alongside the choke and held in place with a sheet metal band. In the base of the cabinet is the three-prong midget battery socket for external battery connection. The upper part of the earphone is placed about one inch down from the top of the cabinet. The antenna insulator must be mounted as shown so that the antenna can telescope inside the set when not

in use. This completes the placement of the parts. The Handie Talkie is then wired conventionally in accordance with the diagram, *Fig. 4*.

Details of Cabinet

The entire cabinet can be cut out of a section of sheet aluminum (.05″-18 ga.) 15 by 15 inches. Left over aluminum can be used to make the two angle-brackets for the tube sockets. Referring to *Fig. 5*, the cabinet consists of two L-shaped sections (*Detail 1*) and two cover sections (*Detail 2*). The L-shaped sections are easy to bend to shape as shown, but the two cover sections present more of a problem, In order to get the lipped or rolled edge on the cover, it is necessary to clamp a section of 1/8″ thick metal 10 inches long along the edges where the lip is required. Then using a ball peen hammer, the soft aluminum is hammered or rolled up against the metal guide. This is repeated until both covers have their long edges rolled to form approximately a 1/16″ lip Then the metal guide is cut down to 3 inches in length and clamped in place at the ends of the covers; and the above process is repeated. Since aluminum is soft, slight mistakes in bending can easily be corrected by hammering. The sharp corners, where the rolled edges meet, are then hammered over to give a smooth surface. Next fit the L-sections to the covers so that they nest together properly. After the parts are installed, two rods 3/16″ diameter, 3 inches long, with tapped holes in the ends, are located individually about two inches from each end of the cabinet (*Figs. 2* and *3*). These rods secure the covers and

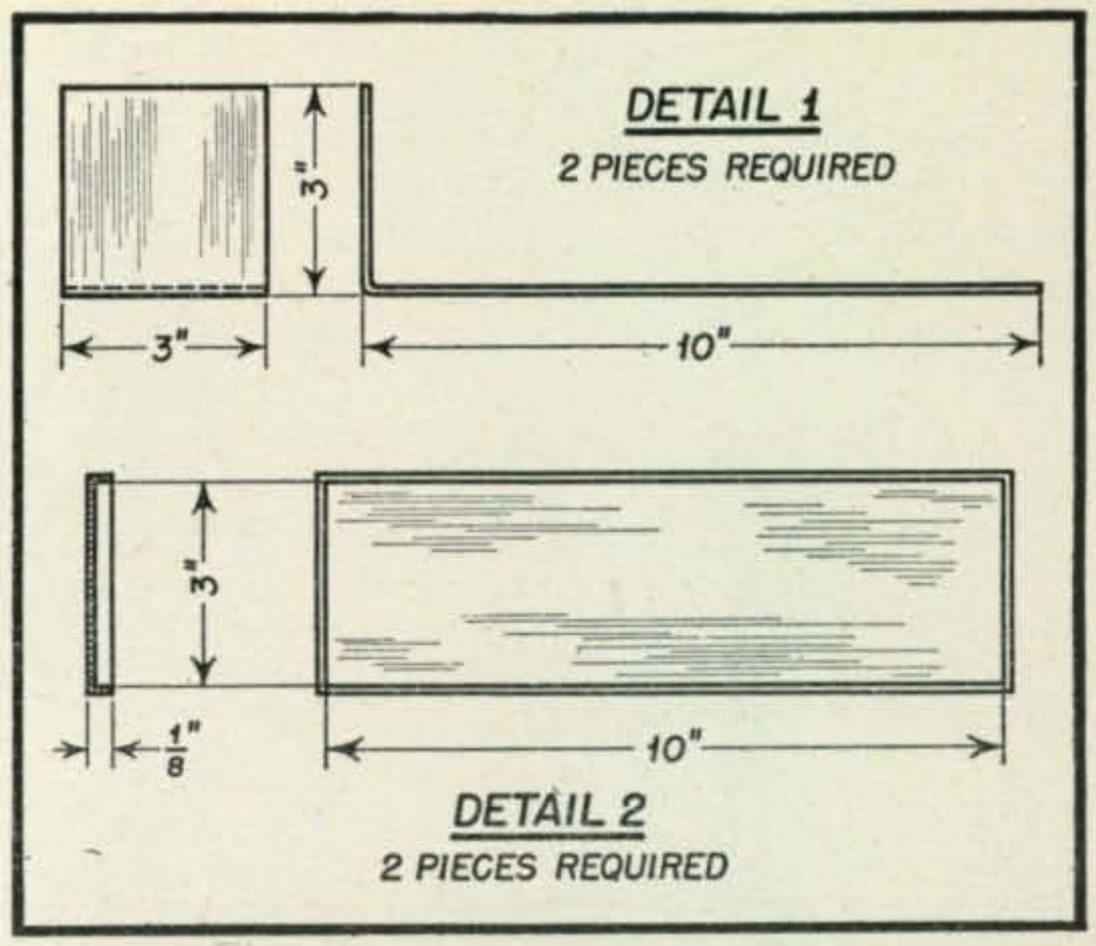


Fig. 5. Plans for the "cabinet." The material is .05″ or 18 gauge soft annealed aluminum sheet

hold the entire cabinet together. However, remember to drill the holes for these tie rods after the parts are installed otherwise some part may interfere with the rods. It is desirable but not necessary to put additional supports near the center of the two covers of the cabinet, as shown in *Figs. 2* and *3*. This completes the cabinet construction.

Microphone Mount

Referring to *Fig. 6*, *Details 1* and *2*, we have the two parts that, when fitted together, constitute the mounting for the microphone. *Detail 1* consists of a cylinder with one end cut off at an angle. If it is laid out to the proper dimensions on a

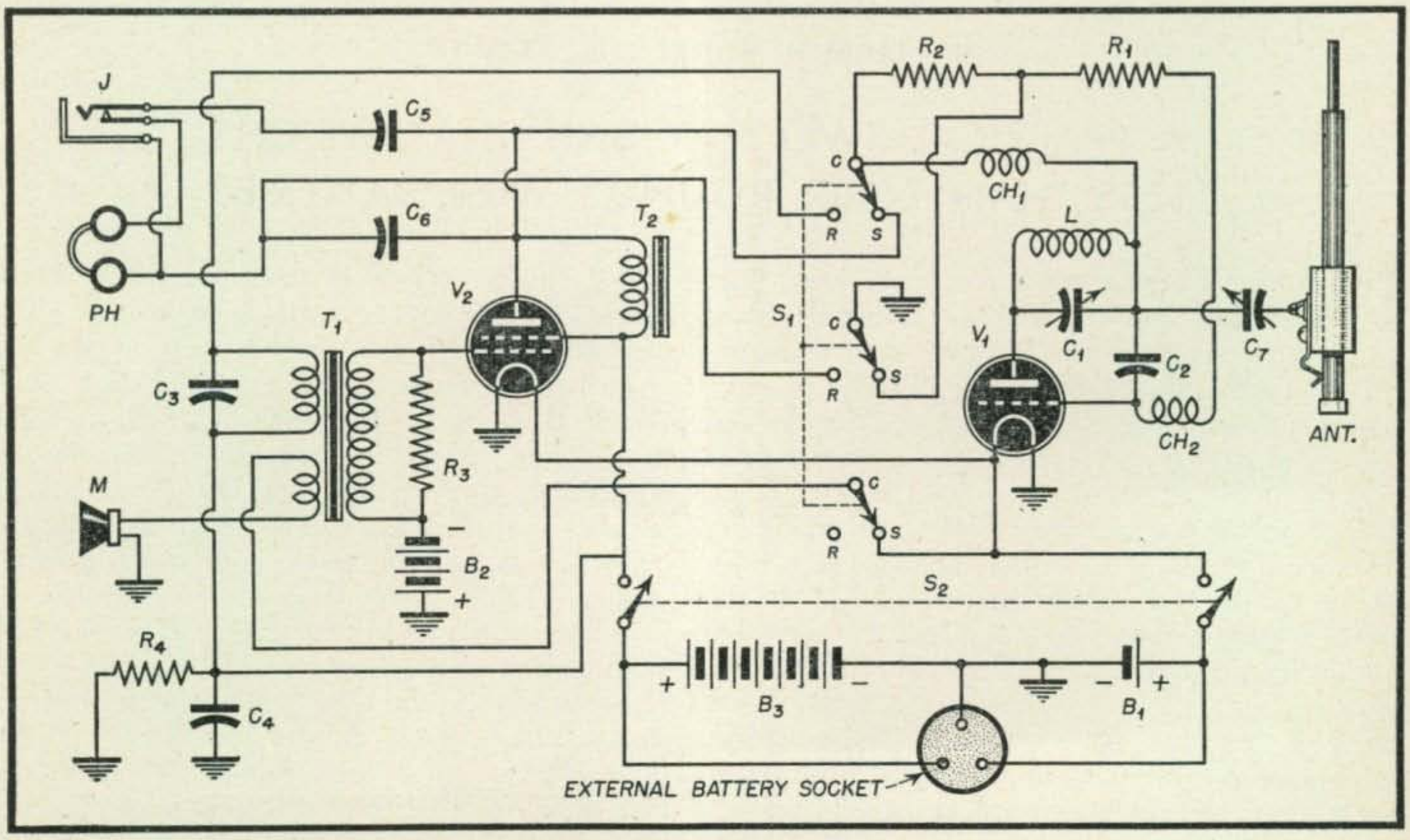


Fig. 4. Wiring diagram of the 144-mc Handie Talkie which can be converted readily to higher frequencies. V_1 is a 958 acorn and V_2 a 1S4 tube

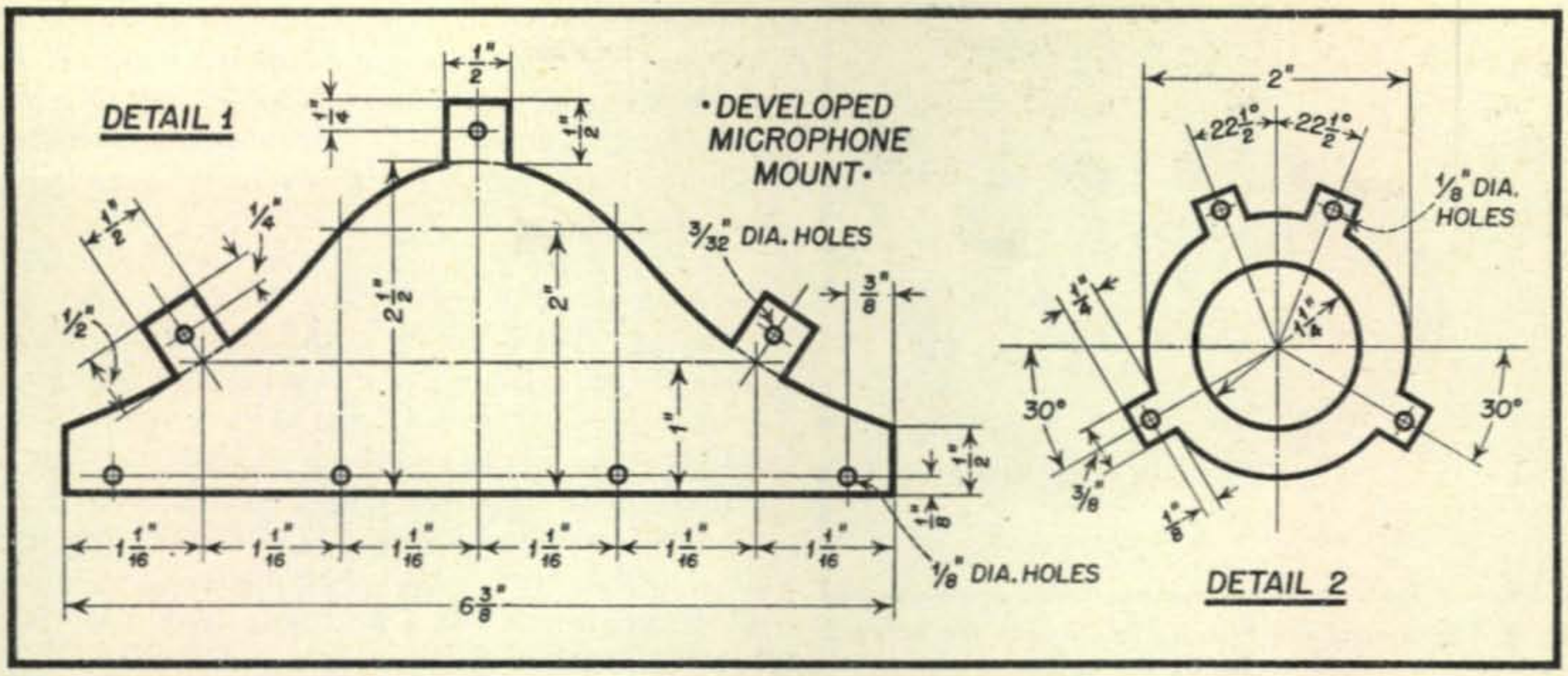
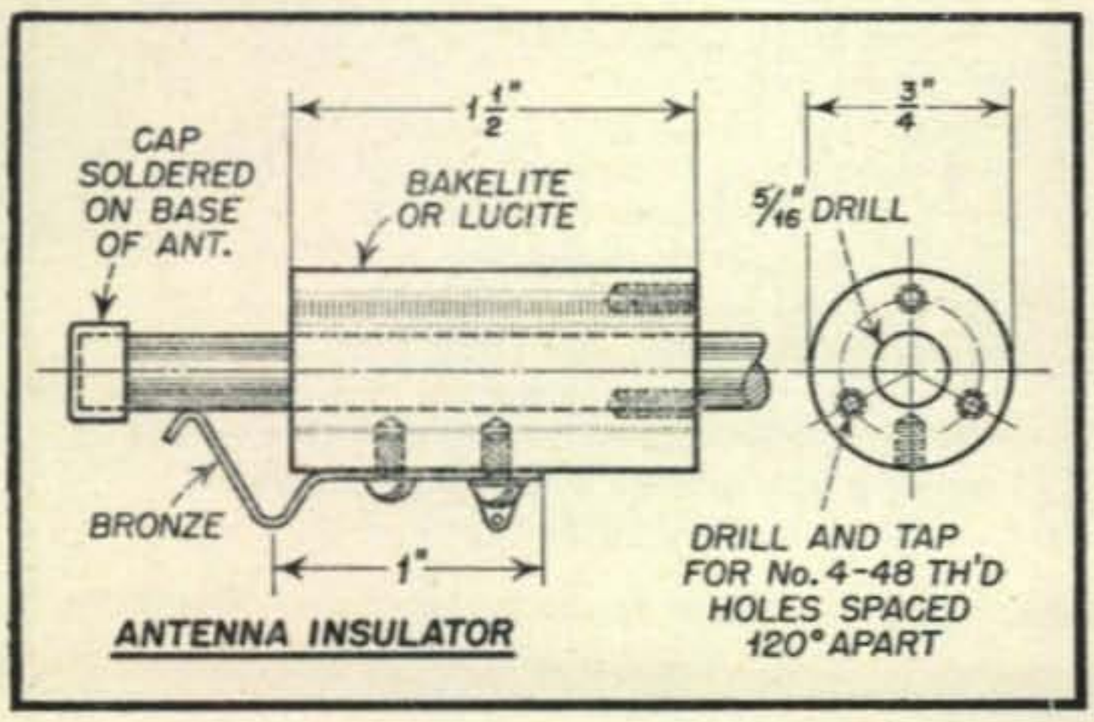


Fig. 6. (above) and Fig. 7. (below) Constructional details of the microphone housing and the antenna insulator. The mike housing was engineered on the drawing board to a custom fit

piece of 1/32" soft aluminum sheet, no problem will arise in its construction. The three tabs (*Detail 1*), bent at right angles to the section, are needed to hold the microphone mount in place on the cabinet. This aluminum can easily be cut with tinsmiths shears. Before the microphone can be mounted on the microphone mount, *Detail 2* will have to be constructed. This too is laid out, per dimensions, on a piece of .05" (18 ga.) aluminum sheet, using a pair of dividers. After cutting out the section with tinners snips, the center hold is made with either a circle cutter or tube-socket punch. Holes are drilled in the four feet (*Detail 2*) and the feet or tabs bent at right angles. This part is now fastened to *Detail 1* (*Fig. 6*), by drilling four holes in *Detail 1* to match the four holes in *Detail 2*, and fastening with 4-48 machine screws and nuts. The F-1 WE microphone is now installed by removing the 1 1/8" nut on the back of the microphone, inserting the microphone through the 1¼" hole in *Detail 2*, and replacing the nut. A wire lead to the microphone button is then soldered in place, and the microphone mount is secured with three self-tapping screws.


CAP SOLDERED ON BASE OF ANT.
BAKELITE OR LUCITE
5/16" DRILL
BRONZE
DRILL AND TAP FOR No. 4-48 TH'D HOLES SPACED 120° APART
ANTENNA INSULATOR

Antenna Insulator

The construction of the antenna insulator illustrated in *Figs. 3* and *4* and sketched in *Fig. 7*, requires no particular explanation. The 5/16" hole through the center of the phenol fiber tube (Lucite would be better—*Ed.*), was drilled on a lathe—but it can be done with a hand-drill or drill-press if held securely when drilling. The metal contact clip to the antenna is fastened to the insulator with screws in tapped holes. The three tapped holes *in the top* of the insulator should be first located by drilling a 3/8" hole in the top of the cabinet where the insulator will ultimately be mounted, and then laying out the three holes with a pair of dividers 120 degrees apart. After these three holes are drilled, they are used to spot the holes which are drilled and tapped in the insulator.

The Antenna

The telescopic antenna was originally 12" collapsed length, and 48" extended. In order to make the antenna nest completely inside the set it is necessary to reduce the collapsed length of the antenna to 6½". When extended the length of this cut-down antenna will be 24" which is more than necessary for a quarter wave on 144 mc. If a telescopic antenna 5/16" diameter and about 6½" collapsed length can be obtained, no alterations are necessary except to solder a small cap or stop on to the end of the antenna to prevent it from coming out of the insulator when the antenna is extended (see *Figs. 2* and *7*).

If the 12" collapsed antenna is the only type available the following must be done. Extend all the antenna sections, and cut the bottom section to an overall 6½" length. The antenna can then be collapsed and the end of the second section seen. This section is also cut off to a length of 6½". Save the small pieces of copper strip stuck through the ends of each section. (These strips must be replaced in the ends of the cut-down

Fig. 8. Top end of the Handie Talkie with the antenna nesting inside the unit

sections.) The antenna is extended again and the next section shortened to a length of 6″. This is repeated for the two remaining sections, with new lengths of 5½″ and 5″ respectively. In reassembling the antenna it is necessary to replace the small pieces of copper strip. This is accomplished by cutting a slit in the ends of the three sections of tubing (excluding the largest section) with a thin bladed jeweler's saw. The depth of the slots is ½″. Assemble the antenna from the small tubing down to the largest tubing. After two tubings are fitted together the copper strip is slipped into the slit and the end is soldered to prevent the strip from sliding out. Repeat this process for the two larger sections of tubing until the entire rod is once again intact. The antenna can then be checked by extending to its maximum length which should be approximately 24″—collapsing to about 6½″, with all the sections nesting inside the largest tubing. The last thing necessary is to solder a small cap at the end of the antenna to prevent it from pulling out of the antenna insulator.

The Finishing Touches

After the parts are mounted and wired, the two studs which limit the rotation of the tuning capacitor to 180 degrees are added. These studs are 4-48 screws in tapped holes so that the rotation of the tuning condenser is limited to half a turn—from maximum to minimum capacity or vice versa. The tuning knob must be in place so that the pointer can be used to locate the two stops. Photo *Fig. 8* shows a view of the tuning capacitor knob, dial, and the two stops.

The leather handle is affixed at this time—cut down from an old leather belt to 12″ in length and about 1″ wide. The ends are folded over and riveted around the two luggage strap holders, as shown in *Fig. 9*. If regular strap holders are not available, two may be bent into shape from a brass strip 3/8″ wide by 1/16″ thick. These are secured to the cabinet with self-tapping screws. The cabinet is now painted a plain black or black crackle finish and left to dry for twenty-four hours. Four rubber feet are then glued on the bottom of the cabinet with ordinary household cement.

The name-plates are easily contrived by lettering on a piece of good white drawing paper in India ink. The lettering in this case was accomplished with a Keuffel and Esser lettering guide. A small border is drawn around each label. Cut out the name-plates and dip in clear shellac, providing a protective, shiny surface which will not smear when wet or damp. The name-plates are glued in place with household cement or a suitable substitute. Lay out the tuning dial plate on drawing paper with India ink and mark in the divisions—breaking down the scale into ten divisions and then each division in half, thus ending up with a total of twenty divisions. The actual frequency values can be marked on the dial plate only after the capacitor is calibrated. Another view of the complete rig is photographed in *Fig. 10*.

Operating Comments

With the 958 acorn tube as detector and oscillator, operation at 225 mc is just as easy as at 144 mc. The writer expects to operate this Handie Talkie around 450 mc with only slight changes in circuit characteristics.

Inside the Handie Talkie

C_1—modified Hammarlund APC 25 $\mu\mu$f midget. All plates except one rotor and one stator plate removed so that the spacing between plates is 3/32 inch.
C_2—100 $\mu\mu$f midget mica.
C_3—.003 μf mica.
C_4—.005 μf mica
C_5—.1 μf paper 100 volts.
C_6—.01 μf paper 100 volts.
C_7—3-30 $\mu\mu$f trimmer.
R_1—25,000-ohm ½-watt.
R_2—1-megohm ½-watt.
R_3—100,000-ohm ½-watt.
R_4—100,000-ohm ½-watt
L—144-148-mc coil, 4 turns #14 enameled 5/8″ dia. 1″ long.
CH_1—Bud UHF choke.
CH_2—Bud UHF choke.
T_1—transceiver transformer (Stancor #3833).
T_2—Midget a.c.-d.c. choke (Stancor #1723).
S_1—4PDT rotary switch (Centralab).
S_2—DPDT midget slide-type switch (ICA #1260).
J—open circuit jack (ICA #1902).
B_1—1½-volt flashlight cell (size D).
B_2—3 1½-volt penlite batteries.
B_3—67½-volt Minimax battery (#467 Eveready).
PH—single headphone 2000 ohms or higher.
M—Western Electric microphone #F-1.

[*Parts shown are those actually used. Others of equivalent performance may be substituted.*]

Handie Talkie Features

1. Low-cost tubes and parts.
2. Simple circuit—three controls and two tubes.
3. Weight less than four pounds including batteries.
4. Low operating cost. Power consumption same as average portable radio.
5. Provision for external batteries for fixed or semi-portable operation.
6. Microphone and earphone mounted on the cabinet.
7. Compact—ten inches high by three inches square.
8. Telescopic antenna nests inside the cabinet when not in use.
9. Provision for external earphones.
10. Bandspread over 180° 144-148 mc. Dial is calibrated directly in megacycles.
11. Unit can be operated with one hand.

No difficulty should be experienced in getting this unit to receive and transmit at the correct frequency if the circuit is followed. When the Handy Talkie is operating properly with the antenna extended to approximately ¼ wave length, the plate currents drawn by the two stages in receive and send positions are as follows:

958 Detector—1 ma	958 Oscillator —6 ma
1S4 Audio —9 ma	1S4 Modulator—9 ma

The total B battery requirements in send and receive positions are 18 ma and 13 ma respectively. The additional milliamperes over and above the current drawn by the two tubes are consumed in resistors and the screen circuit of the 1S4 tube. There is plenty of modulation available to drive the 958 oscillator, as can be seen by comparing the plate currents of the two tubes. It is possible to raise the plate current on the 958 by reducing the size of the grid bias resistor from 25,000 to 15,000 or 20,000 ohms, but this is not desirable.

Calibrating the Handy Talkie

Several methods can be used to calibrate a 144 mc transceiver. The procedure described here employs a combination of Lecher wires and signal generator, although Lecher wires can be used alone with fairly good results. In either case the Lecher wires are used first to determine the approximate frequency. Since it is almost impossible to couple Lecher wires to a telescopic antenna, it is necessary to have a second transmitter adjusted to the 144-mc band. In this case an MRT-3 transceiver was used with the coil cut down to tune the 144-mc region. The MRT-3 was first adjusted to 146 mc by means of the Lecher wires. This is represented by a distance of 40½" on the Lecher wires. The Handie Talkie is then tuned to pick up the 146-mc signal from the MRT-3 (or any other 144-mc oscillator).

By spreading or compressing the turns in the tank coil it is possible to pick up the transmitted signal in the center of the dial of the Handie Talkie. After the center of the band has been determined and adjusted on the capacitor tuning dial, the 144-megacycle and the 148-mc extremes of the band are easily determined by the same method. The points on the Lecher wires are 41" distance for 144 megacycles and 40" for 148 mc. When these spots on the tuning dial are known, the dial can be calibrated with reasonable accuracy. With the capacitor plates spaced correctly, it will be found that the 144-148-mc band covers approximately 180 degrees. If the band-spread isn't wide enough, the plates should be forced a little farther apart until the desired band-spread is obtained. On this Handie Talkie the capacitor tunes from 143.7 mc to 148.8 mc over 180 degrees of rotation. Once calibration is achieved slight variations in frequency can be effected by adjusting the coupling capacitor to the antenna. The dial plate is now marked with the actual frequency in megacycles, shellacked and glued in place.

In addition to the Lecher wires the writer employed a Ferris signal generator to check calibration. The signal generator cannot be used unless the approximate frequency is already ascertained

[*see page 46*]

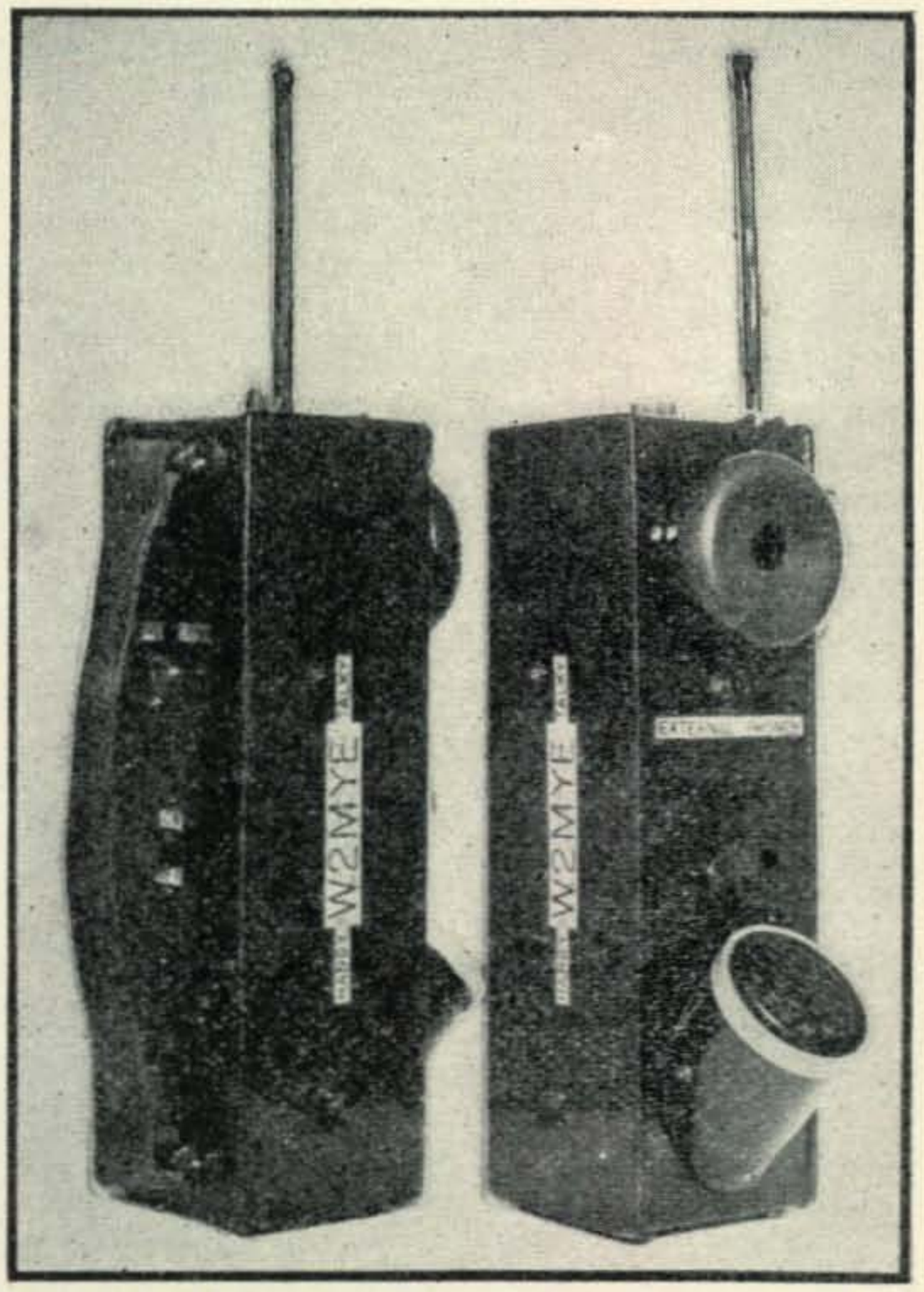


Fig. 9. (left) Rear view shows the carrying strap and the send-receive switch. Fig. 10. (right) The complete rig, with antenna collapsed, is ten inches high—about the size of a "French 'phone"

KNOW

RICHARD E. NEBEL, W2DBQ-WLNB

NEXT TO THE VACUUM TUBE, one of the most widely used components in the radio, power and electronic fields is the indicating meter. In most cases, newcomers to the field of radio learn the use of meters long before their operating principles are understood. A discussion of the functions and capabilities of these instruments will lead to more intelligent applications in practical work. Wider use of a single instrument will be outlined, as well as design and component fabrication for a number of simple multi-meter circuits. Those connected with radio-electronic work come in contact with many different types of meters. Illustration *Fig. 1* shows how basic types are applied to a multiplicity of measurements. Some of these instruments will function in both alternating and direct-current circuits. Others are suitable for a.c. or d.c. only. One basic meter movement may be used for several purposes—the difference being in the external components, such as shunts, multipliers, rectifiers, thermocouples and transformers.

The D-C Vane Meter

This type of meter is not very accurate but it serves satisfactorily in some requirements. The d-c vane meter employs a permanent magnet. It is therefore polarized, and will indicate only when current flows through it in one direction, limiting its utility to direct current. The pointer (*Fig. 2*) is attached to a small, elliptical iron vane. The vane aligns itself with the magnetic flux between the poles of the magnet. When no current flows through the coil the pointer is at zero on the scale. As current flows through the coil in the proper direction, the fixed flux lines are distorted and revolve in a clockwise direction due to the

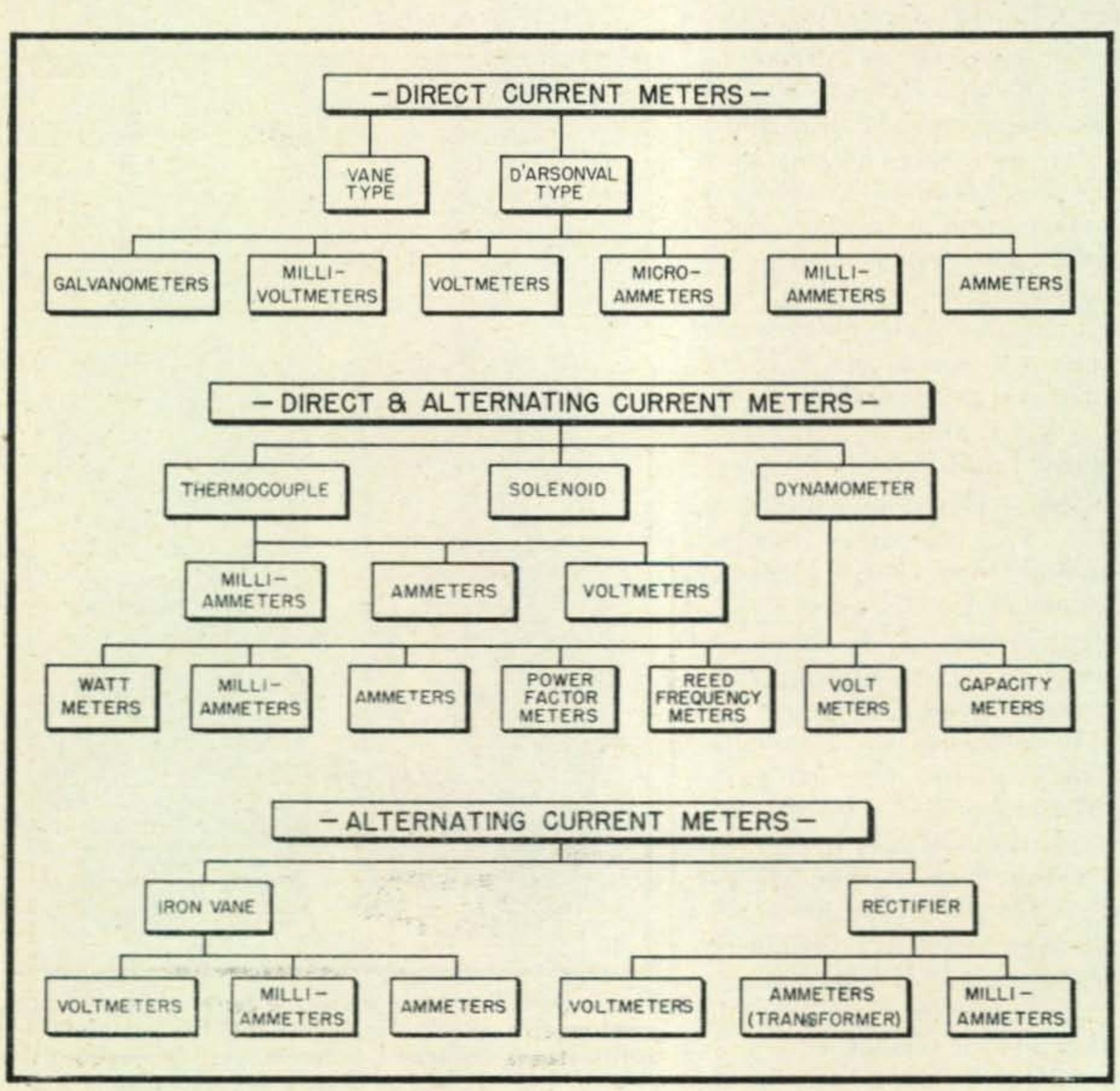


Fig. 1. The family tree of meters. Basic types of indicating instruments

YOUR METER

SHUNTS AND MULTIPLIERS MAKE A SINGLE METER A VERSATILE INSTRUMENT

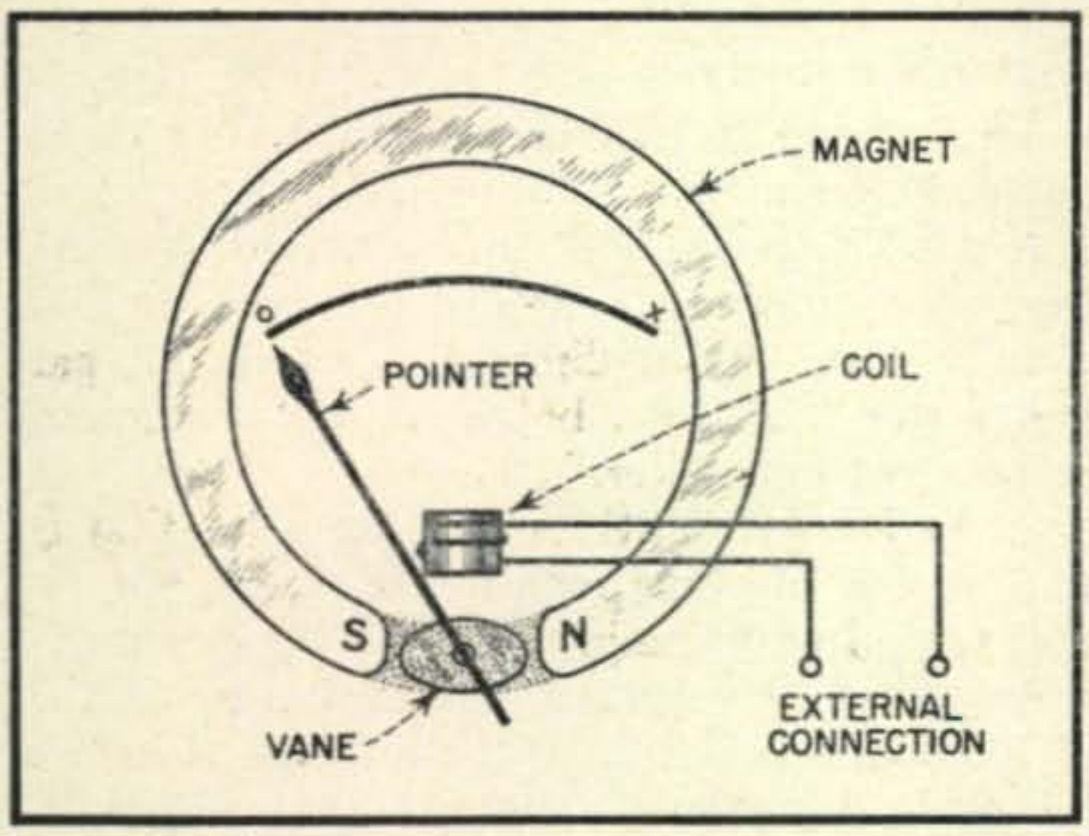


Fig. 2. Direct-current vane-type meter

interaction of the coil flux on the fixed field. The extent of this distortion is dependent on the strength of the coil field which in turn varies with the current flowing through it. The pointer will therefore move upscale as current flows through the coil, the degree of displacement depending directly upon the amount of current. The coil may consist of many turns (to obtain high impedance) if the meter is applied as a voltmeter, or of few turns if used as an ammeter. This type of meter is subject to considerable inaccuracy due to the magnet becoming weak with age or overloads.

The Solenoid Meter

Radio men are familiar with the inexpensive watch-case meter used for testing batteries, etc. This meter is not polarized, as it contains no permanent magnet, and is therefore suitable for both a-c and d-c measurements. The principle of operation is illustrated in *Fig. 3*. As current flows through the coil (solenoid), the soft iron vane is drawn in by magnetic attraction and the pointer moves across the scale, the spiral spring providing the restoring force. The number of turns and size of wire in the coil determine whether it is to be used as a voltmeter or ammeter. The meter may be constructed so as to serve both purposes, having two windings. A meter of the solenoid type, while not very accurate, is rugged and will stand a great deal of abuse.

The A-C Iron Vane Movement

In a-c power work, where sensitivity is not too important but accurate readings are required, the alternating-current vane meter serves very well (*Fig. 4*). Two soft iron vanes are employed, one stationary and the other attached to the pointer shaft. As current passes through the coil, the vanes are magnetized, the upper and lower ends of the two vanes always having the same polarity, regardless of the direction of current flow. As like poles repel, the moving vane is revolved on the shaft carrying the pointer. The restoring force is a spiral spring. A mechanical variation of this system uses two soft iron concentric segments instead of the flat vanes.

The D'Arsonval Meter

The D'Arsonval movement is the most ac-

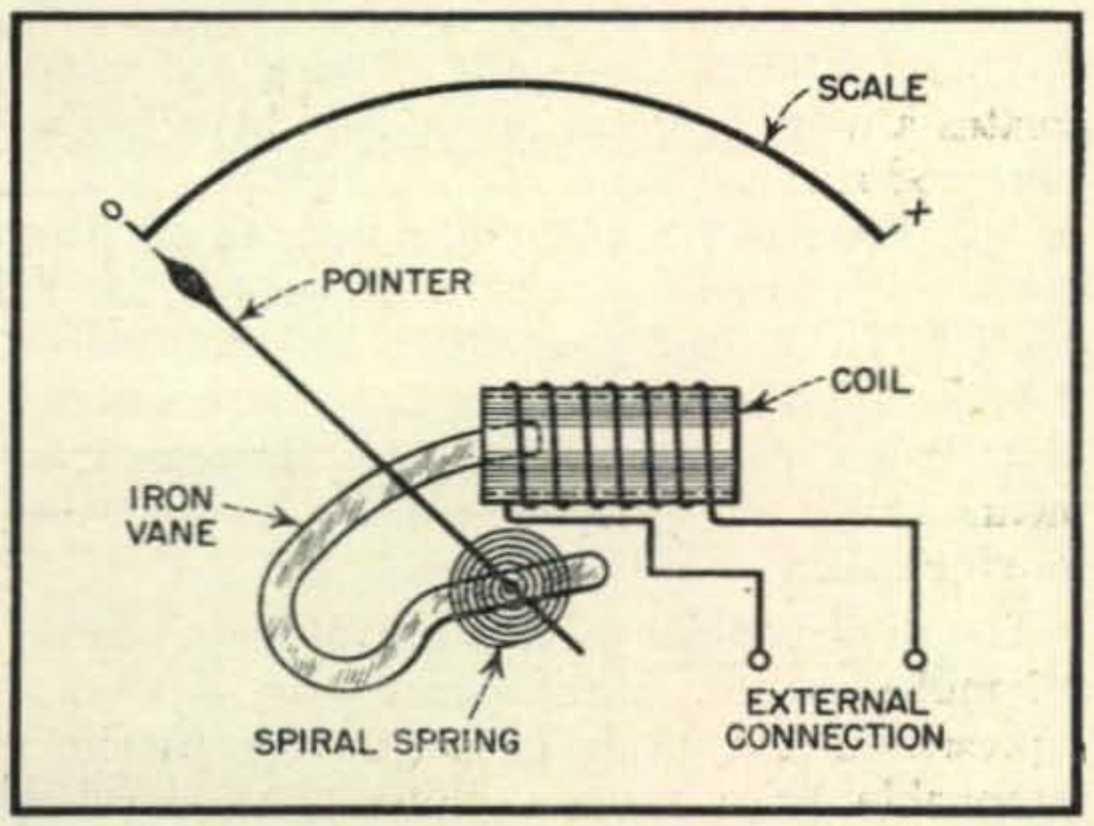


Fig. 3. The solenoid meter is used on both alternating current and direct current

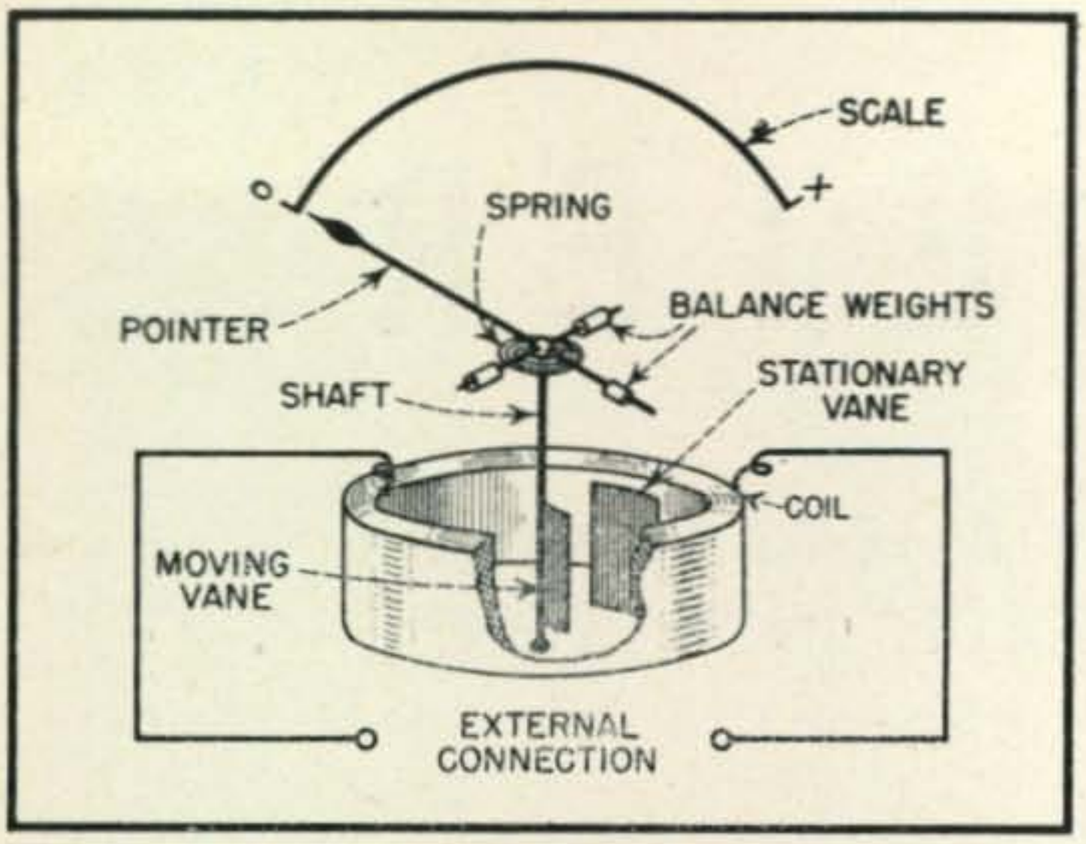


Fig. 4. Iron vane meter for alternating current applications

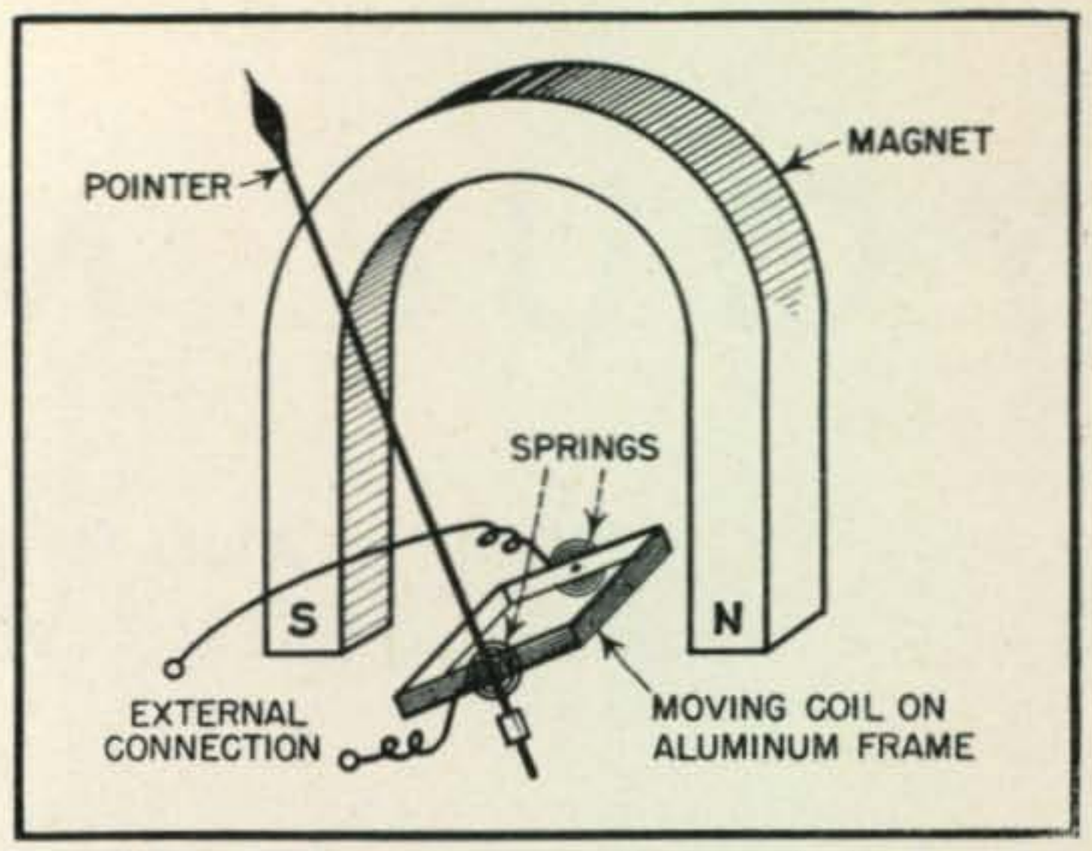


Fig. 5. The D'Arsonval meter is widely employed in d-c equipment

curate and sensitive of all types and is the meter in widest service. As it employs a permanent magnet for producing torque in the moving element, it is polarized and can therefore be used directly on d.c. However, a-c application is made possible by use of thermo-couples and rectifiers.

The basic principle and parts of the D'Arsonval meter are shown in *Fig. 5*. Torque is produced by the permanent magnet, acting on the field produced by current flowing through the moving coil. If the current flows through the coil in the proper direction, the coil assembly, to which the pointer is attached, will move in a clockwise direction. The restoring force is contributed by the two springs which also serve to carry the current to the moving coil. These springs must be precisely fabricated and matched in order to insure accuracy of the instrument. It will be noted that the pointer, attached to the moving coil frame, will come to rest at a point where the actuating magnetic force is balanced or equalled by the opposing force of the springs. Therefore the pointer will move farther for a given current if the springs are made weaker or if the magnetic force is made greater. The latter is accomplished by using a stronger magnet or increasing the number of turns on the moving coil which creates a more dense magnetic field by means of increased ampere-turns. To say that the pointer moves farther for a given current is to say that the sensitivity is increased. Inasmuch as the density of the fixed magnetic field is limited by the size and design of the magnet, the sensitivity of ordinary panel-type meters is increased by means of lighter springs and more turns on the moving coil.

The most popular of D'Arsonval meters is the 0-1 milliammeter. Until recent years this range represented the peak of sensitivity within a reasonable price range. Subsequent developments, however, have brought more sensitive micro-ammeters within the reach of all.

Meter Sensitivity

The sensitivity of indicating meters is designated by one of the following methods:

1. GALVANOMETERS: Current required for deflection of one scale division, each division usually being one millimeter in width. A galvanometer may thus be rated as "one microampere per millimeter."

2. VOLTMETERS: Ohms-per-volt—that is, the number of ohms required in the circuit per volt of full scale range. Thus a 0-1 ma meter when used as a voltmeter will have a sensitivity of 1000 ohms per volt. If the meter is to have a full scale deflection of 100 volts, the total resistance in the circuit must be 100,000 ohms. It will be noted that this will limit the current flowing to 1 ma which is also the current required for full scale deflection when 100 volts are applied.

3. MILLIAMMETERS: The milliamperes necessary for full scale deflection. Note the above mentioned milliammeter, 0-1 ma. i. e.,

The lower the sensitivity of a meter the more power is drawn from the circuit in which it is connected. Drawing power from a circuit changes the constants to a degree depending upon its regulation. If the power consumed changes the value being measured, it is obvious that an erroneous reading will result. It can thus be seen that more and more sensitive indicating meters have been sought in order to attain higher degrees of accuracy.

Meter Accuracy

Meter accuracy is usually specified as a percentage, such as 2%—this figure applying to most of the ordinary panel type meters in use by amateurs. It should be noted that this percentage applies to the *full scale reading*. For example, a 2% D'Arsonval meter reading 0-100 volts will be accurate within plus or minus 100 x .02 = 2 volts. At full scale this is of course 2% but at one-half scale (50 volts) 2 volts equals 4%. At one-

tenth full scale (10 volts) the error can be 20% and still meet the manufacturer's guarantee. It is not to be construed, however, that the meter *will* be this inaccurate; but it is possible and therefore in order to obtain reliable measurements the ranges of the meter should be such that the readings will be well upscale. D'Arsonval meters are very delicate instruments and should be accorded the proper protection. Special meter fuses are available ("Littlefuse") and should be used wherever possible. As a guide to selection of the proper fuse, *Table I* is presented.

Meter Shunts

It is often desired to increase the range of a milliammeter or, in a "universal" test instrument, one meter may be used on a number of different ranges. This is accomplished by means of shunts, that is, fixed resistances connected directly across the meter. The calculation of these shunt values is far more simple than actually producing the shunt at the exact value arrived at by calculation. The formula used in calculating shunt values follows:

$$R_s = \frac{E_m}{I_f - I_m}$$

where R_s = resistance of shunt (in parallel with meter), E_m is the voltage required to deflect meter full scale, I_f = full-scale current range desired, and I_m is the full-scale current of the meter (E and I in volts and amperes respectively).

In order to calculate E_m it is necessary that the internal resistance of the meter be known inasmuch as $E = IR$. The internal resistance of some common meters is shown in *Table II*.

As an example, assume that a Jewell, Pattern 88, 0-1 ma meter is to be used as a 0-100 ma meter. From *Table II* the internal resistance is 30 ohms. $E_m = .001 \times 30 = .030$ volts. It will be noted that the meter is also, fundamentally, a 0-30 millivolt meter.

$$R_s = \frac{.030}{.100 - .001} = .303 \text{ ohms.}$$

As mentioned previously, it is far easier to calculate the shunt value than to produce the shunt. The best shunts are made of low temperature-coefficient alloy wires and calibrated on a Kelvin bridge. The following method, however, is quite practical and will serve with sufficient accuracy for general use.

Ordinary cotton or silk covered magnet wire may be used, the required length being "finger-wound" and bound with thread. A copper-wire table, found in any radio engineering textbook, shows the resistance of all sizes of copper wire per thousand feet. Dividing the value by 1000 gives the resistance per foot, and the desired shunt value is arrived at by linear measurement. The largest size wire practical should be used for greatest accuracy, the bulk of the resulting shunt limiting the wire size. As an example, 1000 feet of #24 wire has resistance of 26.17 ohms. One foot = .02617 ohm. A typical .12-ohm shunt may consist of .12/.02617 = 4.585 feet of #24 wire.

Shunts constructed by this method can be only approximately correct. For utmost precision the shunt should be adjusted in comparison with a meter of known accuracy. The leads from shunt to meter terminals must be considered as part of the shunt.

Multipliers

To extend the voltage range of low reading milliammeters, multipliers are used *in series* with the meter. For highest accuracy wire-wound precision resistors are employed. If the application does not warrant this expense, carbon multipliers can be used. In this case it is necessary to measure them on a bridge. When the exact ohmage is not available, lower values may be filed until the desired resistance is reached. If metallized resistors are used they may be matched in

TABLE I

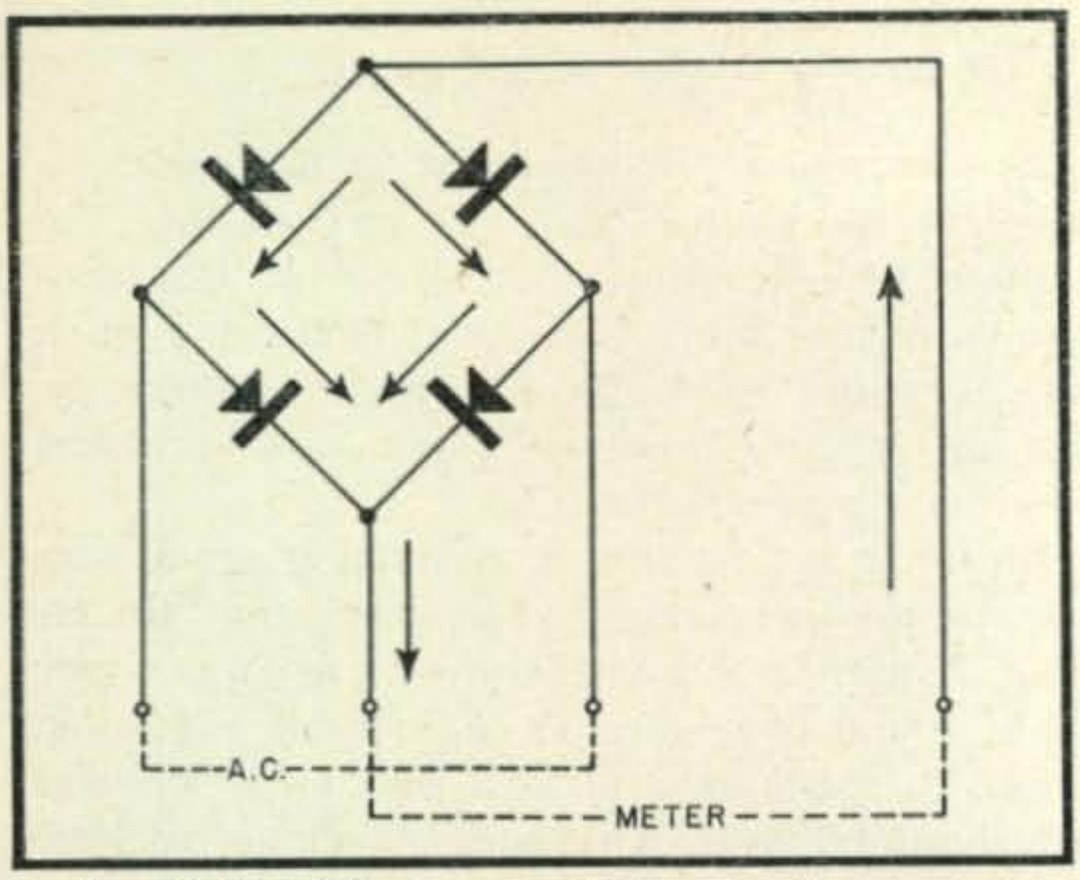
METER FUSE SELECTION

METER RANGE - MA.	FUSE VALUE - AMPS.	APPROX. FUSE RESISTANCE - OHMS
MICROAMMETERS	1/200	500
0 – 1	1/100	110
0 – 1 – 0 – 10	1/32	20
0 – 10 – 0 – 25	1/16	5
0 – 25 – 0 – 75	1/8	3
0 – 75 – 0 – 150	1/4	6.2
0 – 150 – 0 – 250	3/8	3
0 – 250 – 0 – 350	1/2	2.5
0 – 350 – 0 – 500	3/4	.4
0 – 500 – 0 – 750	1	.24
0 – 750 – 0 – 1000	1 – 1/2	.18

TABLE II

INTERNAL METER RESISTANCE

METER RANGE IN MA.	WESTON MODEL 301	JEWELL PATTERN 88	TRIPLETT MODEL 321
0 – .2	55 OHMS		360 OHMS
0 – .5	55 "		156 "
0 – 1	27 "	30 OHMS	33 "
0 – 1.5	18 "		22 "
0 – 3	18 "		11 "
0 – 5	12 "		8.5 "
0 – 10	8.5 "		3.1 "
0 – 25	1.2 "		1.2 "
0 – 50	2 "		.6 "



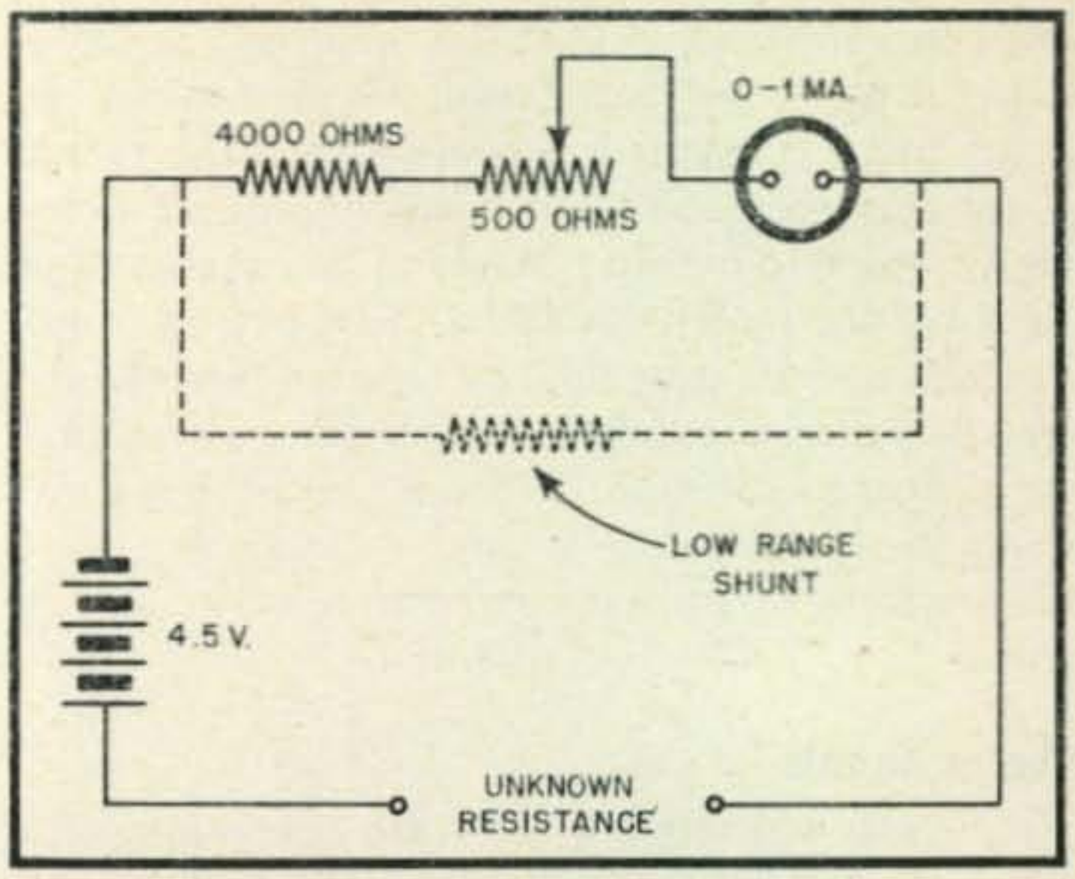


Fig. 6. (left) Bridge circuit showing the operation of a copper oxide rectifier. Fig. 7. (right) Series type ohmmeter. Basic circuit

pairs to obtain the correct value. It is necessary to take into consideration the sensitivity of the meter to determine the wattage of the resistors required. For example, a 125 ohm-per-volt meter may be used for a 0-500-volt range. The required multiplier is 500 x 125 = 62,500 ohms. If 500 volts is applied to the meter-resistor combination to cause it to read full scale, the power that must be dissipated in the multiplier is—

$$P = \frac{E^2}{R} = \frac{500^2}{62{,}500} = 4 \text{ watts}$$

—To be entirely correct, the above mentioned multiplier should be 62,500 ohms less the internal resistance of the meter. However, on high-voltage ranges the meter resistance can be considered negligible and ignored.

In the above example it will be noted that the power dissipated is 4 watts. These 4 watts must be drawn from the circuit under measurement and will affect that circuit accordingly. The influence of the meter on the circuit may be estimated by calculating the actual change in value due to 62,500 ohms being connected in parallel with it. It can be seen that the higher the sensitivity of the meter the less effect it will have on the circuit under measurement and therefore the meter will indicate more truly the actual voltage across it.

Rectifiers

In order to realize the advantages the highly sensitive D'Arsonval meter in alternating current measurements, copper oxide rectifiers are used. These units consist of small discs or squares of copper with a thin coating of copper oxide formed on one face of each. These are put together in a full-wave circuit as illustrated in *Fig. 6*. The direction of current flow is unilateral, that is, much more current will flow from the copper oxide to the copper than vice versa. With a.c. applied as indicated, current flows through the meter in one direction only, and the D'Arsonval meter can now be employed as a measuring instrument.

As is the case with any type of rectifier, the unit has an internal resistance which varies with the current passing through it. This resistance increases inversely with the current; therefore the scale on the meter is cramped at the lower end. The approximate resistance of a rectifier at various currents in connection with a 0-1 ma meter is as follows:

MA	*OHMS*
1.0	500
.9	530
.8	560
.7	620
.6	685
.5	769
.4	870
.3	1030
.2	1300
.1	2000

If the linear scale on the meter is employed for a-c measurements, capacity multipliers will sometimes provide greater accuracy. These multipliers can be used only at the frequency for which they are calculated, such as 60 cycles—the multiplier value being the capacitive reactance of the

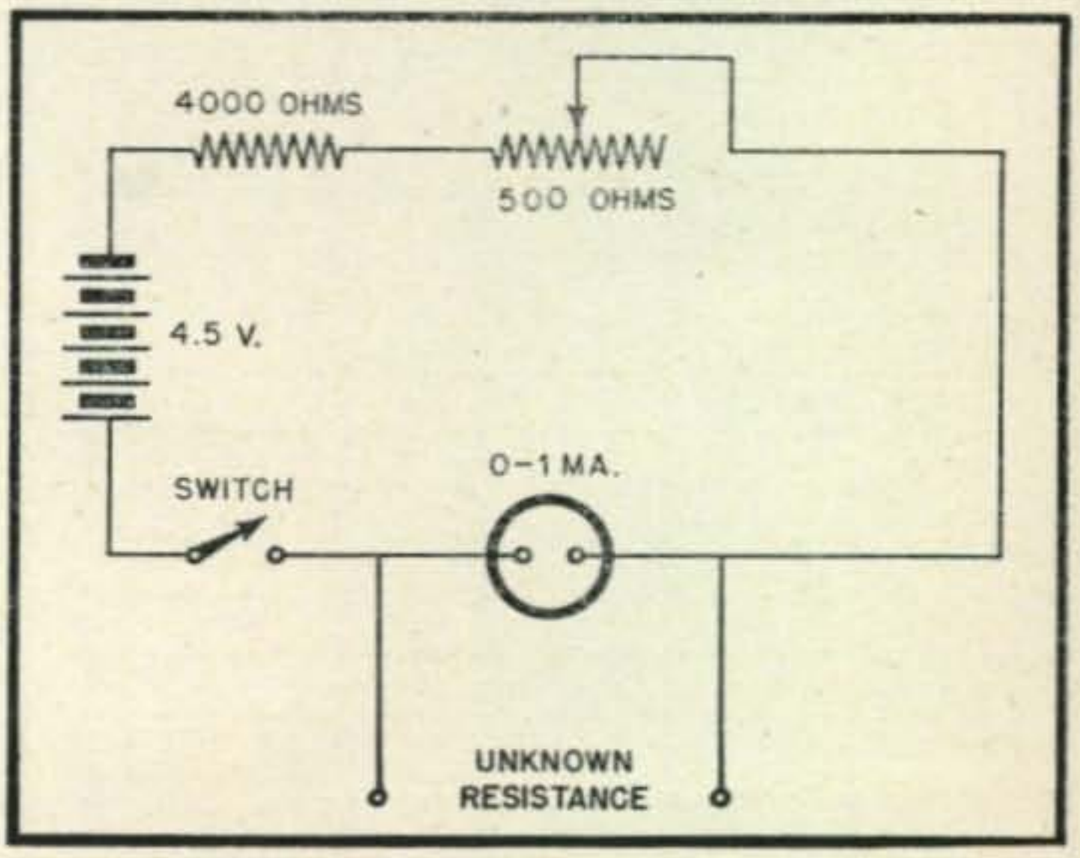
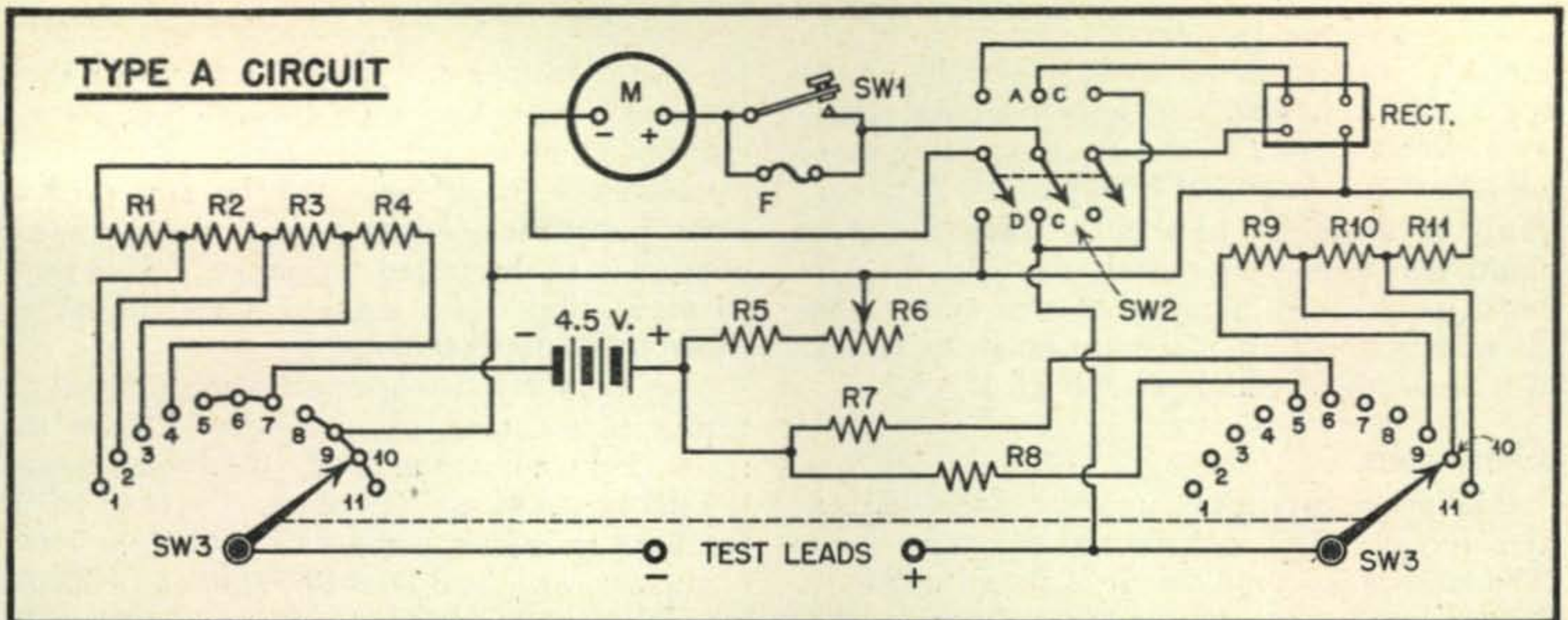


Fig. 8. Ohmmeter in a shunt circuit



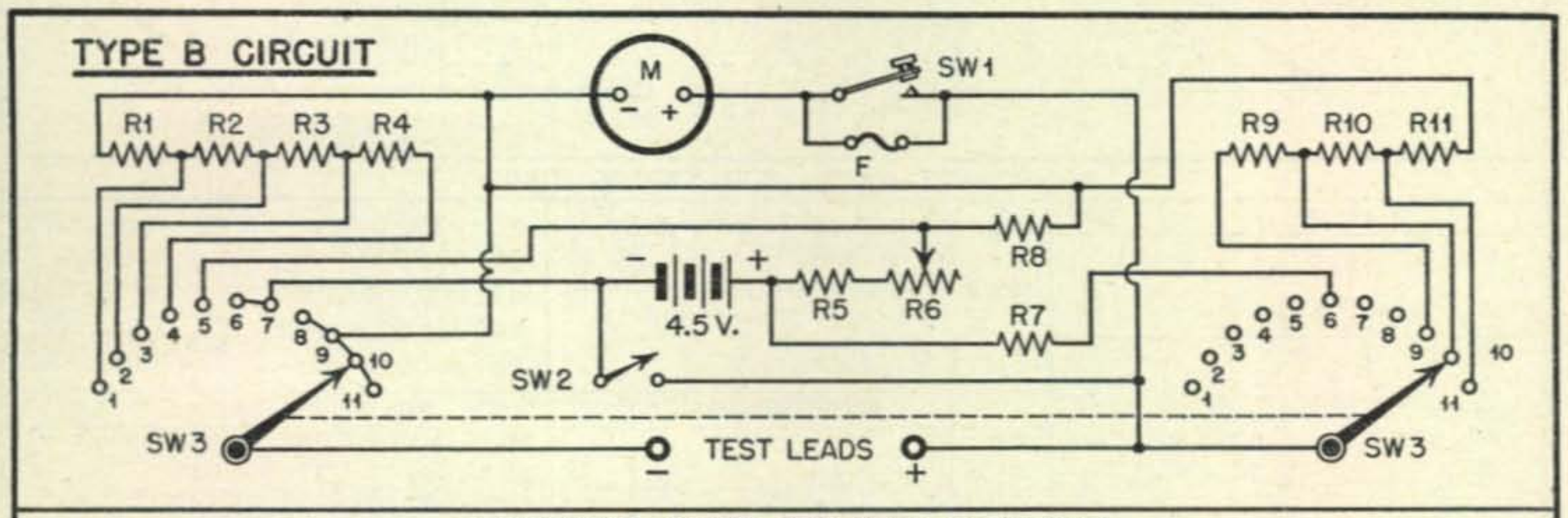
COMPONENT PARTS FOR TYPE A CIRCUIT					
RANGES	SW3	SW1 – PUSH-BUTTON SWITCH Normally open.	R1 – 9970 OHMS	R6 – 750 OHM W.W. POT. (Zero adj.)	
VOLTS – A.C. & D.C. 0–10	1	SW2 – 3P.D.T. TOGGLE SWITCH	R2 – 40,000 OHMS		
0–50	2	SW3 – 2-GANG, 11-POINT SHORTING CONTACT ROTARY SWITCH.	R3 – 200,000 OHMS		
0–250	3	RECT. – COPPER-OXIDE FULL-WAVE METER RECTIFIER.	R4 – 750,000 OHMS	R7 – 500 OHMS	
0–1000	4	F – 1/100 AMP. FUSE.	R5 – 4000 OHMS	R8 – 45.5 OHMS	
OHMS – 0–1000	5				
0–10,000	6				
0–100,000	7				
MA. D.C. – 0–1	8				
0–10	9				
0–50	10				
0–250	11				

	WESTON 301	JEWELL 88	TRIPLETT 321
R9	2.4 OHMS	2.667 OHMS	2.933 OHMS
R10	.48 "	.533 "	.587 "
R11	.12 "	.133 "	.147 "

FIG. 9

Multi-meter circuit—type A

condenser. When using the same resistance multipliers for both alternating and direct currents, the accuracy on a.c. may be increased by shunting the resistors with condensers. Thus the multipliers are not changed in value on d-c measurements but are corrected when applying alternating current, as the condensers become effective parallel shunts across the multipliers, thus reducing their values to take into consideration the resistance of the rectifier and the fact that the a-c reading on the meter is average, not r.m.s. Capacity effects between the elements of the rectifier also tend to make the reading low. It is quite difficult to attain accuracy on a-c measure-



COMPONENT PARTS FOR TYPE B CIRCUIT					
RANGES	SW3	SW1 – PUSH-BUTTON SWITCH Normally open.	R1 – 9970 OHMS	R5 – 4000 OHMS	
VOLTS – D.C. 0–10	1	SW2 – S.P.S.T. TOGGLE SWITCH.	R2 – 40,000 OHMS	R6 – 750 OHM W.W. POT. (Zero adj.)	
0–50	2	SW3 – 2-GANG, 11-POINT SHORTING CONTACT ROTARY SWITCH.	R3 – 200,000 OHMS		
0–250	3	F – 1/100 AMP. FUSE.	R4 – 750,000 OHMS	R7 – 500 OHMS	
0–1000	4				
OHMS – 0–500	5				
0–10,000	6				
0–100,000	7				
MA. D.C. – 0–1	8				
0–10	9				
0–50	10				
0–250	11				

	WESTON 301	JEWELL 88	TRIPLETT 321
R8	23.0 OHMS	20.0 OHMS	17.0 OHMS
R9	2.4 "	2.667 "	2.933 "
R10	.48 "	.533 "	.587 "
R11	.12 "	.133 "	.147 "

FIG. 10

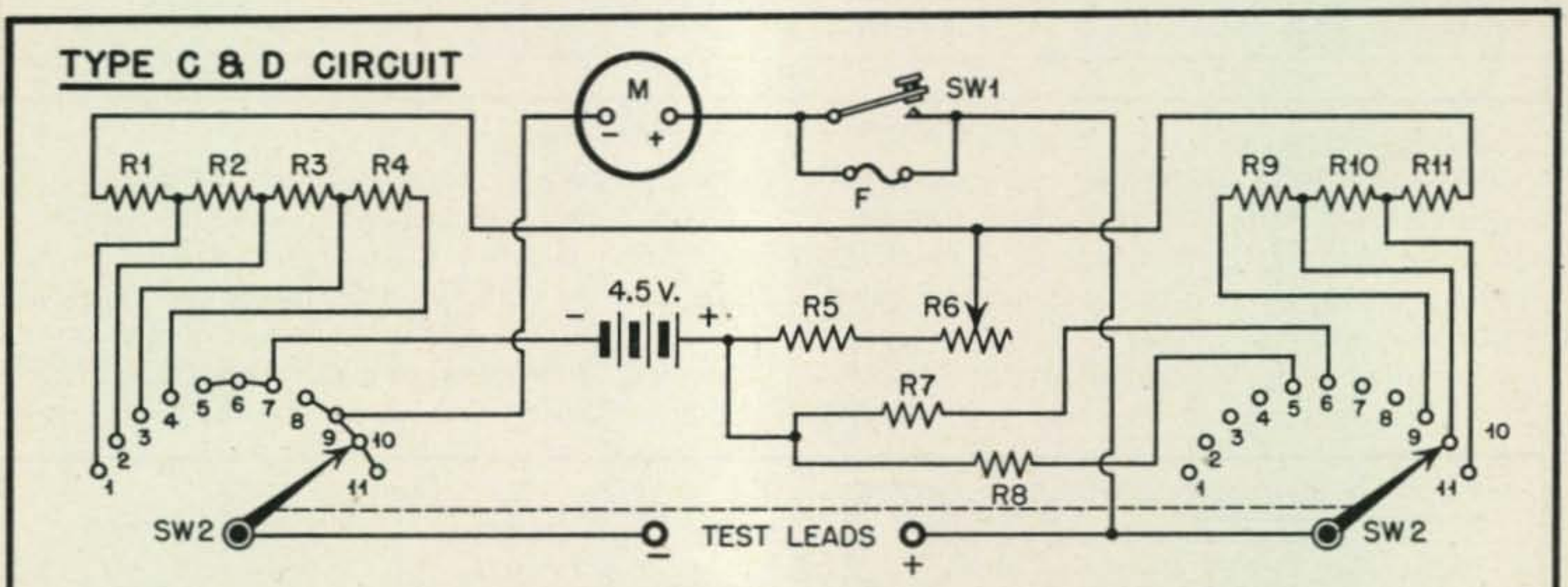
Type B multi-meter circuit. SW-2 is closed only when using 0-500-ohm range. Set meter for full scale as usual

ments in a multi-range circuit, especially on the low ranges, comparable with d-c readings. However errors are reduced to a great extent by use of an off-set a-c scale and it is possible to obtain fairly accurate a-c indications using the same multiplier resistors for both a.c. and d.c. It must be kept in mind that one must compromise in the design of a multi-range instrument if it is not to be unduly complicated.

Ohmmeters

Two general types of ohmmeter circuits are extensively used and are known as series and shunt. The basic series type circuit is shown in *Fig. 7*. Here 4.5 volts are connected in series with 4,500 ohms which limits the current through the meter to 1 ma. The resistance consists of 4,000 ohms fixed and a 500-ohm rheostat. This permits adjustment as the battery voltage drops off with age and use. When shorting the terminals, the rheostat is adjusted so that the meter reads full scale. A resistor connected between the terminals will cause less than 1 ma to flow in the circuit and the meter reading will therefore be lower than full scale, depending upon the value of the resistor being measured. By simple mathematical calculation a linear scale may be calibrated in ohms, but it is customary to use a direct reading ohm scale as illustrated farther on. This basic circuit is suitable for resistance measurements between 0 and 100,000 ohms.

As very low resistance values are difficult to read with accuracy, it is possible to shunt the meter circuit so as to make the total resistance of the circuit less than 4,500 ohms. For example, if the total resistance is reduced to 450 ohms the ohmmeter range will be 0-10,000 ohms, utilizing a multiplying factor of .1 on the original scale. This is accomplished by means of a shunt of 500 ohms across the meter and the 4,500 ohm resistance which is in series. Note that the current through the meter when the terminals are shorted will still be 1 ma, but the current through the external circuit will now be 10 ma. If the meter circuit is shunted to a total value of 45 ohms, the ohmmeter range will be 0-1000 ohms but the



COMPONENT PARTS FOR TYPE C CIRCUIT

RANGES	SW2
VOLTS - D.C. 0-10	1
0-50	2
0-250	3
0-1000	4
OHMS - 0-1000	5
0-10,000	6
0-100,000	7
MA. - D.C. 0-1	8
0-10	9
0-50	10
0-250	11

SW1 - PUSH-BUTTON SWITCH Normally open.

SW2 - 2-GANG, 11-POINT SHORTING CONTACT ROTARY SWITCH.

F - 1/100 AMP. FUSE.

R1 - 9970 OHMS
R2 - 40,000 OHMS
R3 - 200,000 OHMS
R4 - 750,000 OHMS
R5 - 4000 OHMS
R6 - 750 OHM W.W. POT. (Zero adj.)
R7 - 500 OHMS
R8 - 45.5 OHMS

	WESTON 301	JEWELL 88	TRIPLETT 321
R9	2.4 OHMS	2.667 OHMS	2.933 OHMS
R10	.48 "	.533 "	.587 "
R11	.12 "	.133 "	.147 "

COMPONENT PARTS FOR TYPE D CIRCUIT

RANGES	SW2
VOLTS - D.C. 0-15	1
0-150	2
0-300	3
0-600	4
OHMS - 0-1000	5
0-10,000	6
0-100,000	7
MA. - D.C. 0-1	8
0-15	9
0-150	10
0-300	11

SW1 - PUSH-BUTTON SWITCH Normally open.

SW2 - 2-GANG, 11-POINT SHORTING CONTACT ROTARY SWITCH.

F - 1/100 AMP. FUSE.

R1 - 14,970 OHMS
R2 - 135,000 OHMS
R3 - 150,000 OHMS
R4 - 300,000 OHMS
R5 - 4000 OHMS
R6 - 750 OHM W.W. POT. (Zero adj.)
R7 - 500 OHMS
R8 - 45.5 OHMS

	WESTON 301	JEWELL 88	TRIPLETT 321
R9	1.735 OHMS	1.929 OHMS	2.121 OHMS
R10	.097 "	.107 "	.118 "
R11	.096 "	.107 "	.118 "

FIG. 11

Multi-meter circuit—types C and D

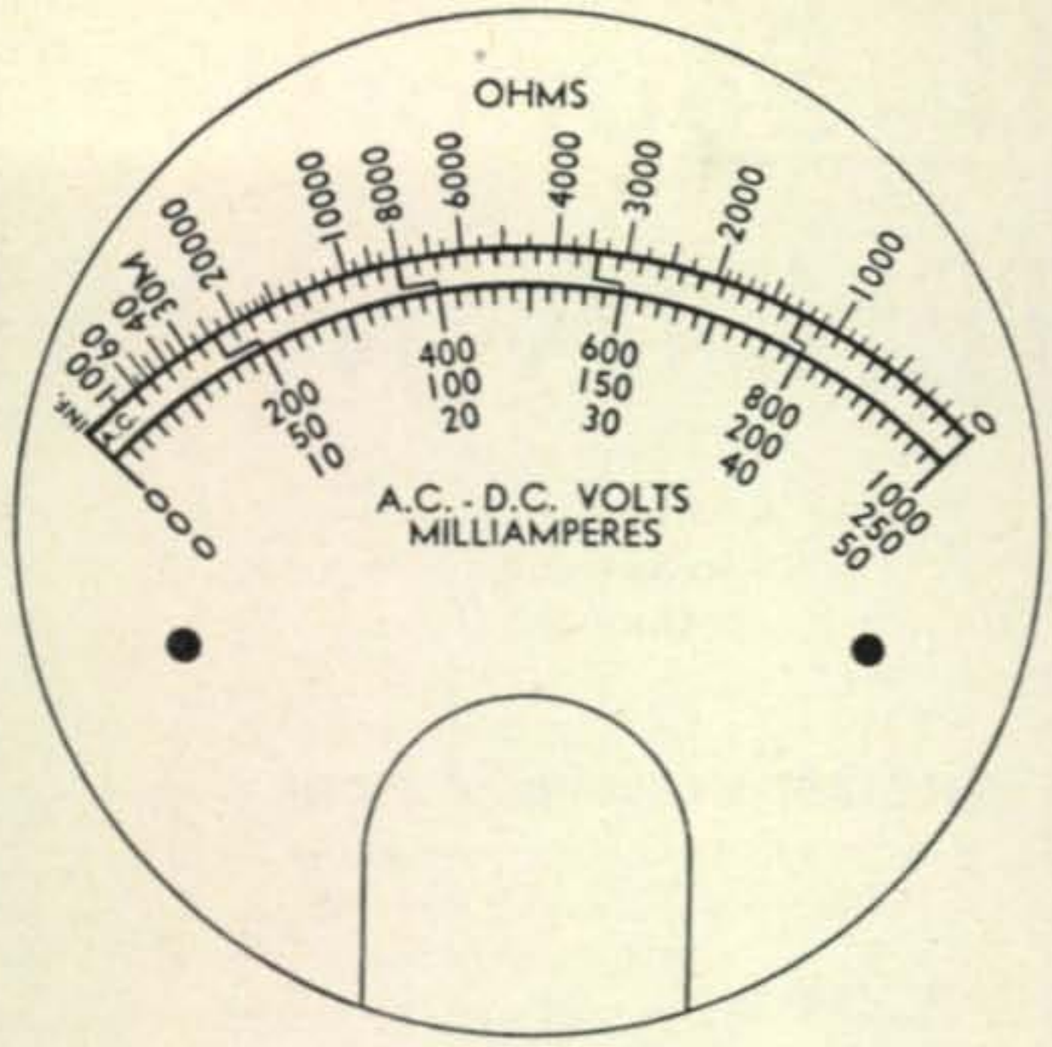


Fig. 12. Type A scale

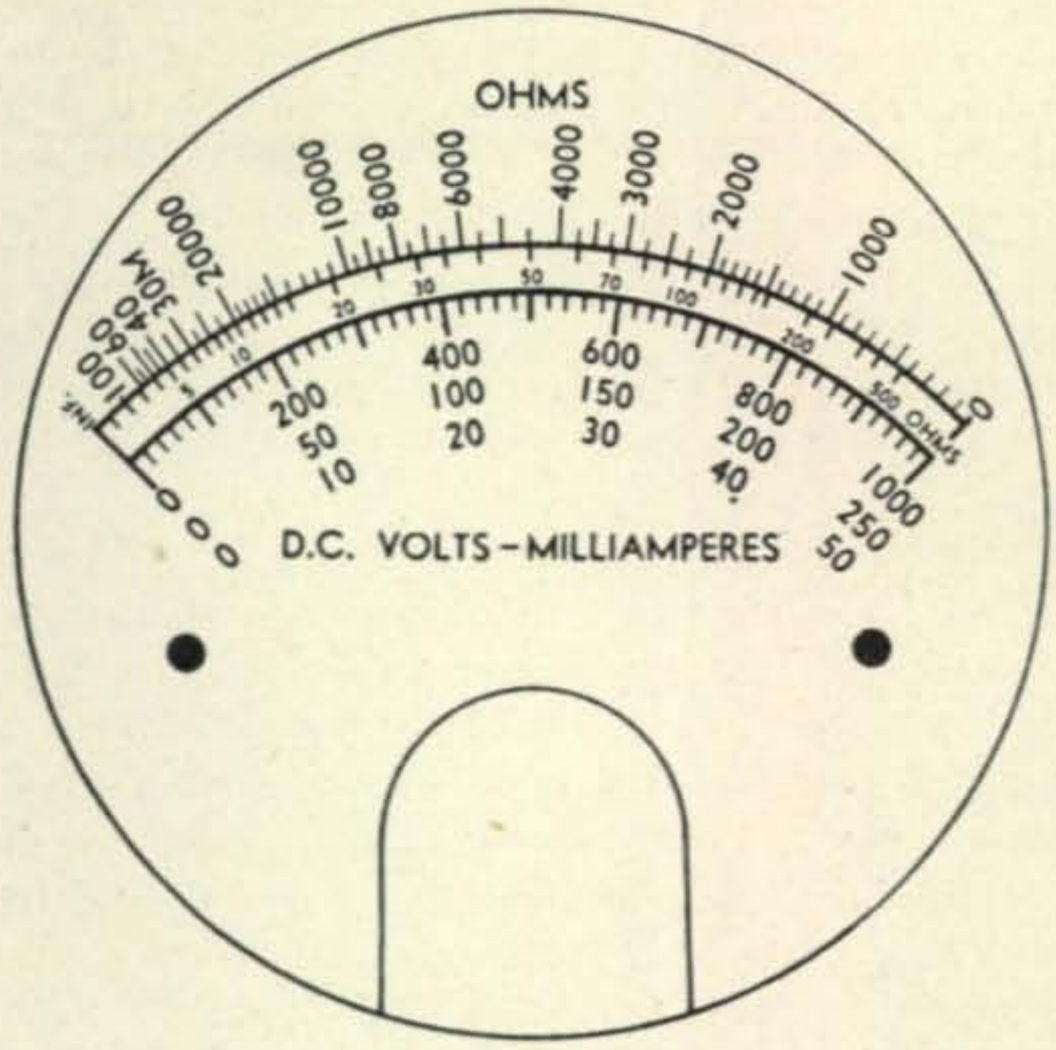


Fig. 13. Type B scale

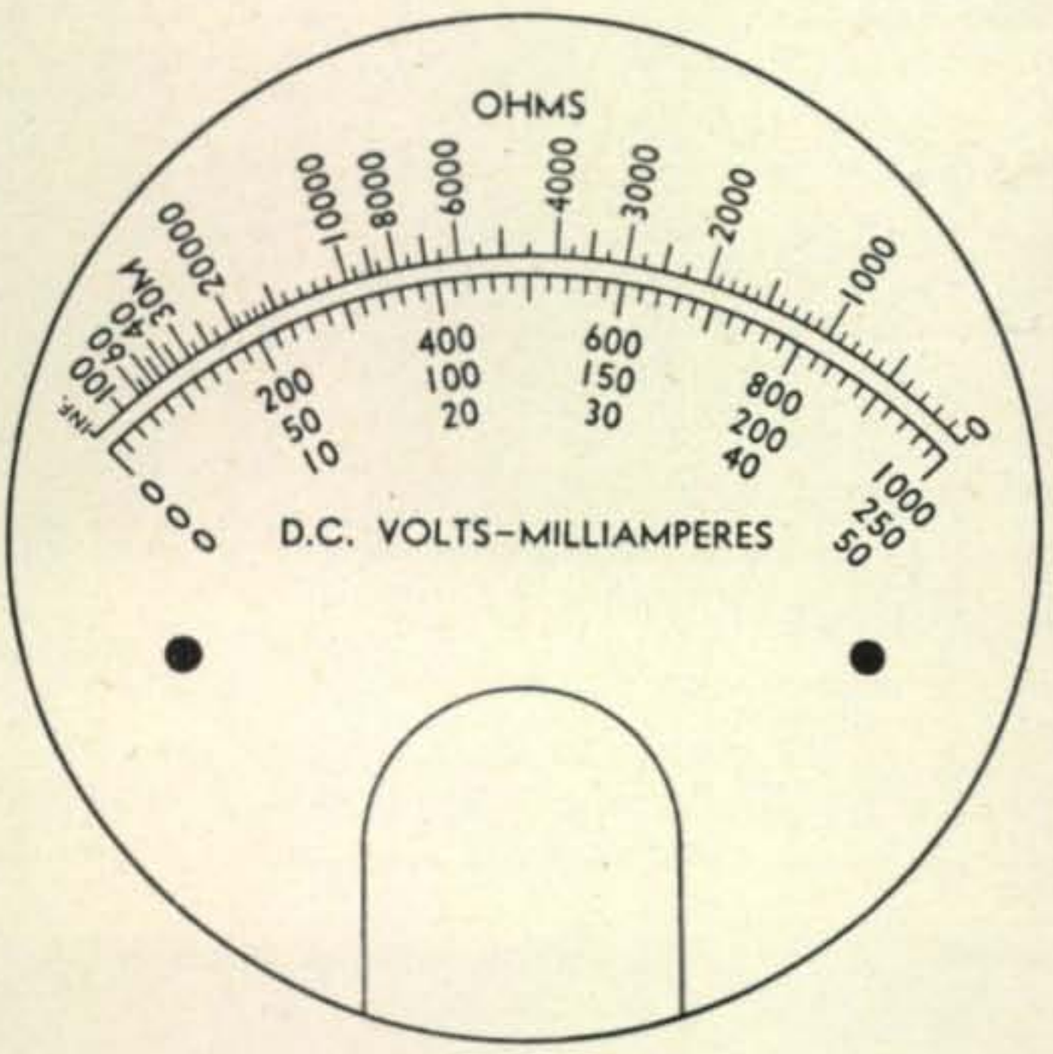


Fig. 14. Type C scale

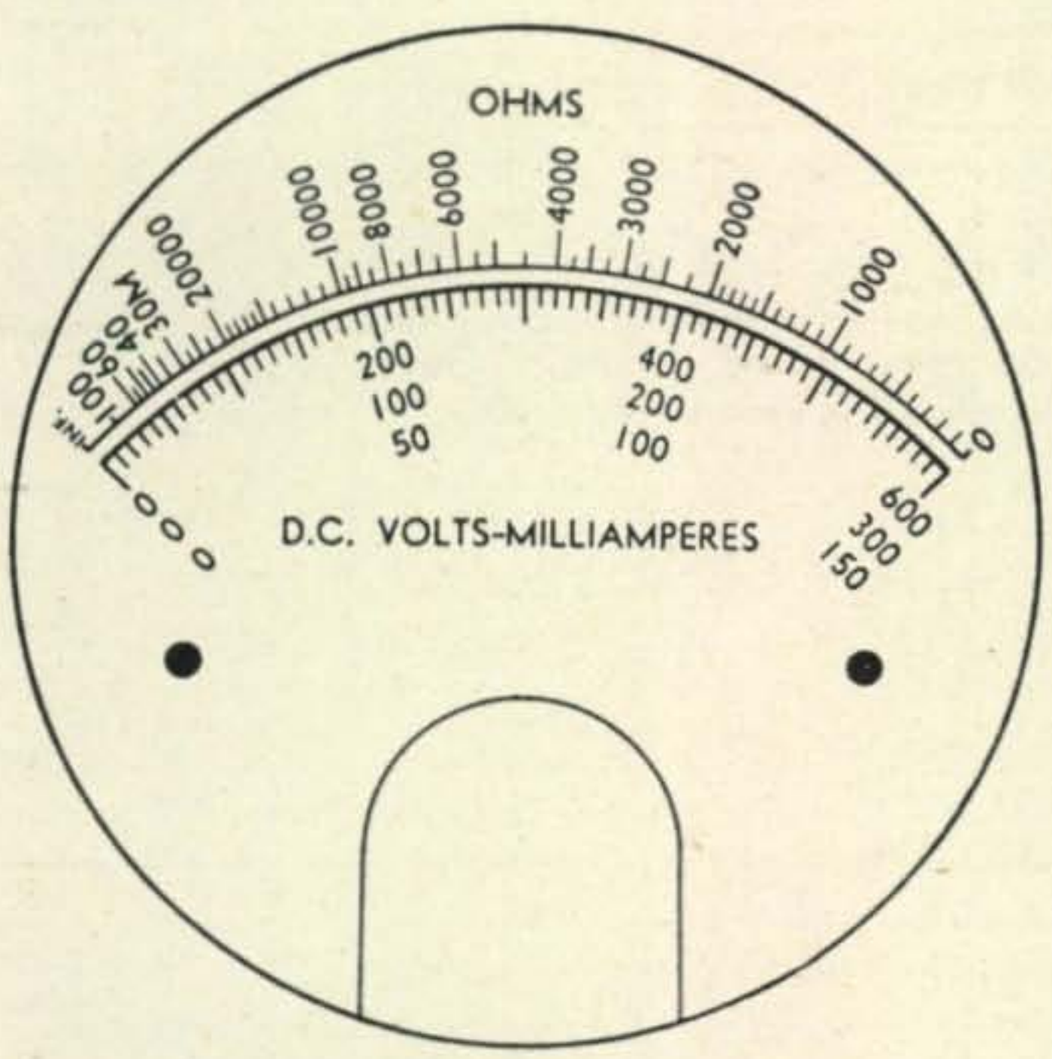


Fig. 15. Type D scale

Special scales for milliammeters. These are drawn to exact size for several models in general use

current through the external circuit will be 100 ma. It is therefore necessary to ascertain whether the device being measured is able to stand this high current without damage. The battery drain is also very high.

If high current on low resistance measurements cannot be tolerated, recourse may be taken to the shunt ohmmeter circuit illustrated in *Fig. 8*. The same resistors and meter are employed but the unknown resistor is shunted directly across the meter. The range of this circuit is 0-500 ohms and its main advantage is that only 1 ma flows through the external circuit.

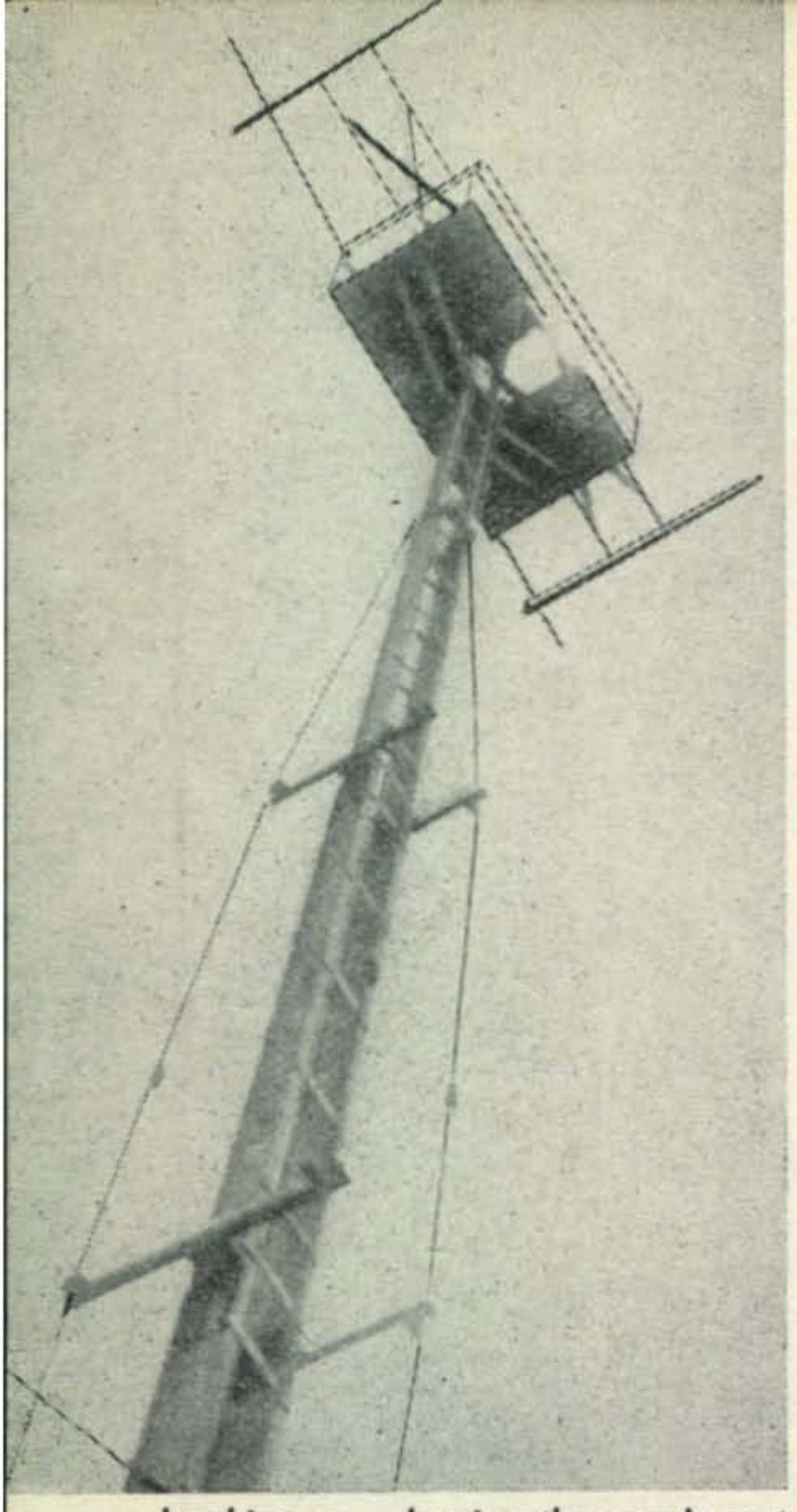
If it is desired to read values higher than 100,000 ohms the series circuit may be employed with higher voltages. For example, with 45 volts and 45,000 ohms in the circuit, the range will be 0 to 1 megohm. With 450 volts and 450,000 ohms the range is increased to 10 megohms. Extended ranges may be had without using high voltages by employing a more sensitive meter. If a 100

[see page 43]

Self-Supporting ANTENNA MAST

WILLIAM KESSLER,* W2ECR

A PERMANENT SIXTY-FIVE-FOOT ALL-STEEL STRUCTURE FOR ROTARY BEAMS

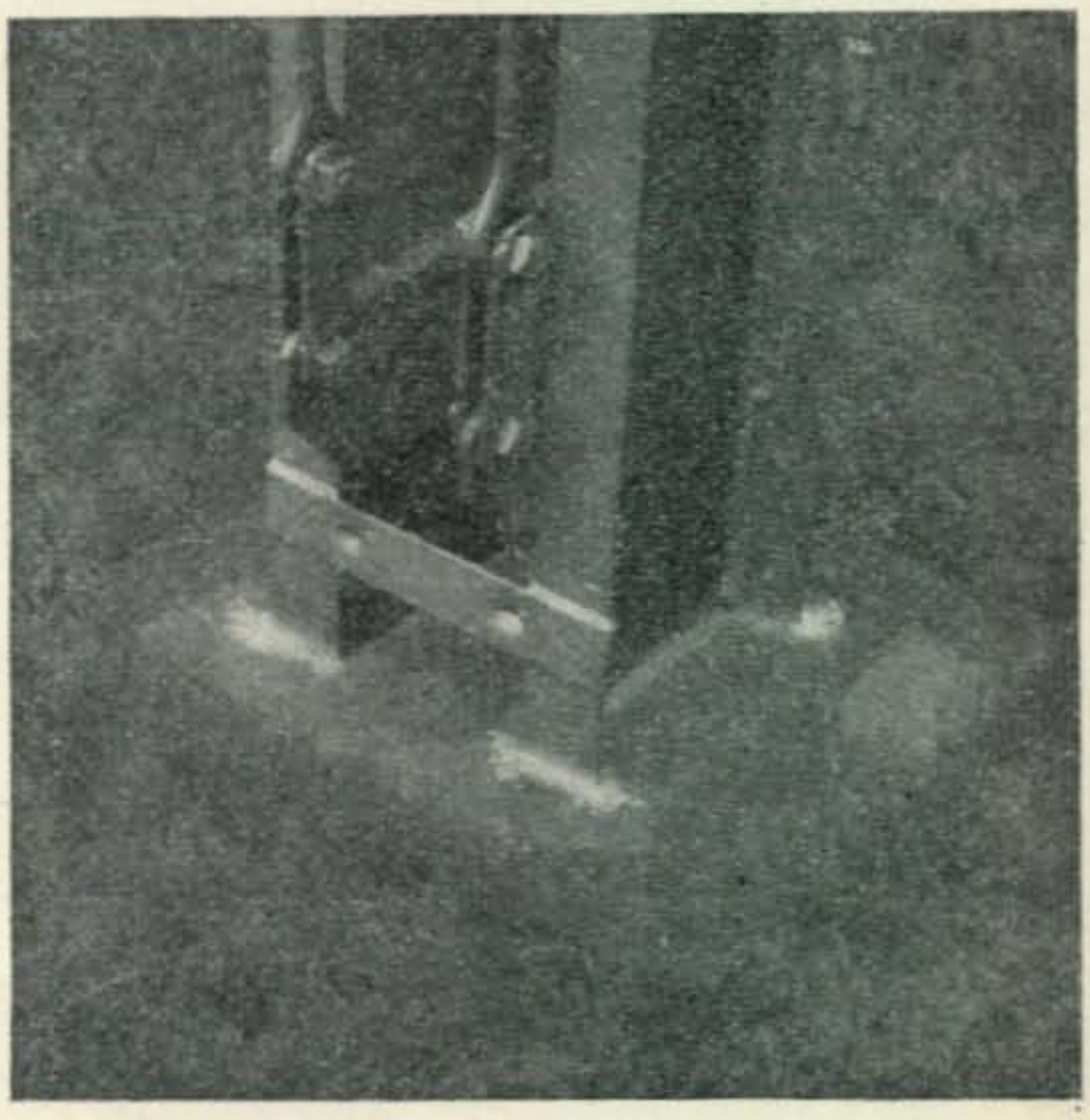


Looking up—showing the crow's nest and the rotary beam antenna. Guys, ordinarily, are not required

THE SIXTY-FIVE-FOOT steel antenna mast at W2ECR is a permanent installation for ambitious amateurs. The assistance of an accomplished welder and a contingent of helpful hams is the primary requisite. The first consideration, even before planning, is to obtain their co-operation. This should be followed with a thorough investigation of local zoning restrictions to determine if laws exist pertaining to a mast this size. The wisdom of this move *before* erecting the pole is obvious! If a building permit is required—obtain one. Cover all the angles, because this is an ambitious project representing considerable effort.

Base Section

The tower is constructed of six sections of steel channels, welded in pairs, and bolted one to another. The base is embedded in a concrete mixture of rock and stone, approximately 30" by 30" and seven feet deep. After the base sec-



The base section of this antenna mast is set seven feet deep in the concrete block

(Right) This is a permanent installation. Pay off your mortgage and obtain a building permit if necessary

tion is placed and plumbed with a spirit level, it must be allowed to set for several days.

Straps are bent under the channels and welded at both ends. Each strap is 2½" wide. The base section channels are 7½" apart on their inside face. Four feet of the base section remains above ground, *seven feet being buried in the concrete.* Raising the mast, section by section, will require help, preferably experienced in the use of a block and tackle. A winch is secured to the base section by means of large U bolts. A steel cable, with a hook on the end, is threaded through a heavy-duty eye-bolt and pulley on top of a 20 foot 4 x 4 (or larger) pole. The hook is then fastened into a bolt hole on the section to be raised. Hoisted to the proper level, it is secured to the base (or section below) by eight ¾" bolts and flat washers.

The Crow's Nest

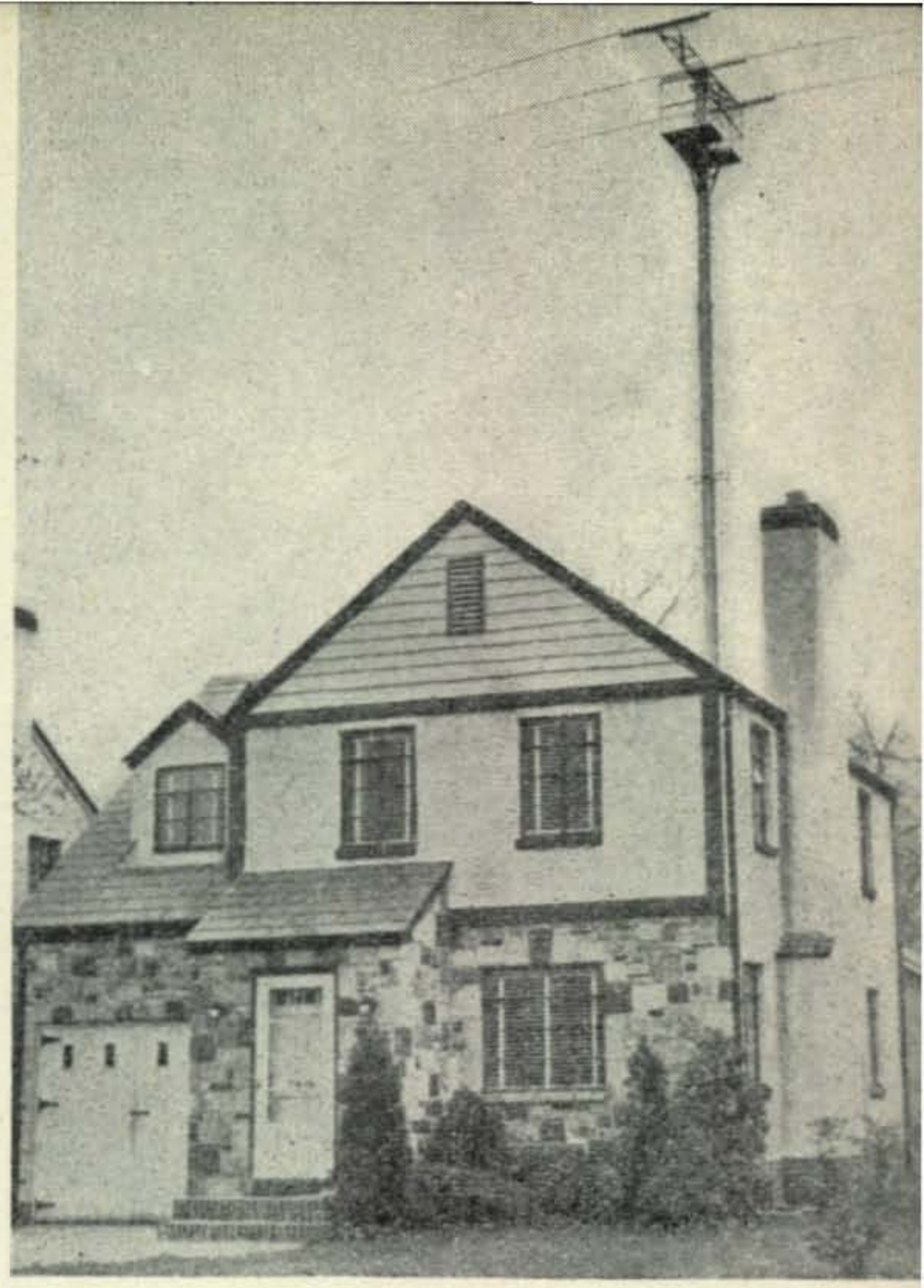
All the sections are raised in the same manner, including the crow's nest, which is constructed and secured to the top section, 4 feet from the top, while still on the ground. It is made of angle iron, with a wooden floor 72" x 40". An opening is cut for admittance. On the extreme top of the mast, a steel plate is bolted for mounting the motor of a rotary beam. Steps to the crow's nest are provided by the cross straps. Climbing without a safety belt should not be attempted under any circumstances.

Two plates 18" x 7" are welded to the base section, with turnbuckles placed in the eyes on the plates. The plates at the top, for securing the outriggers, are bolted to the last section. Crossarms are bolted to the center section. No guy wires are used in this installation, but they may be added if desired. If used, it is important to break them frequently with strain insulators.

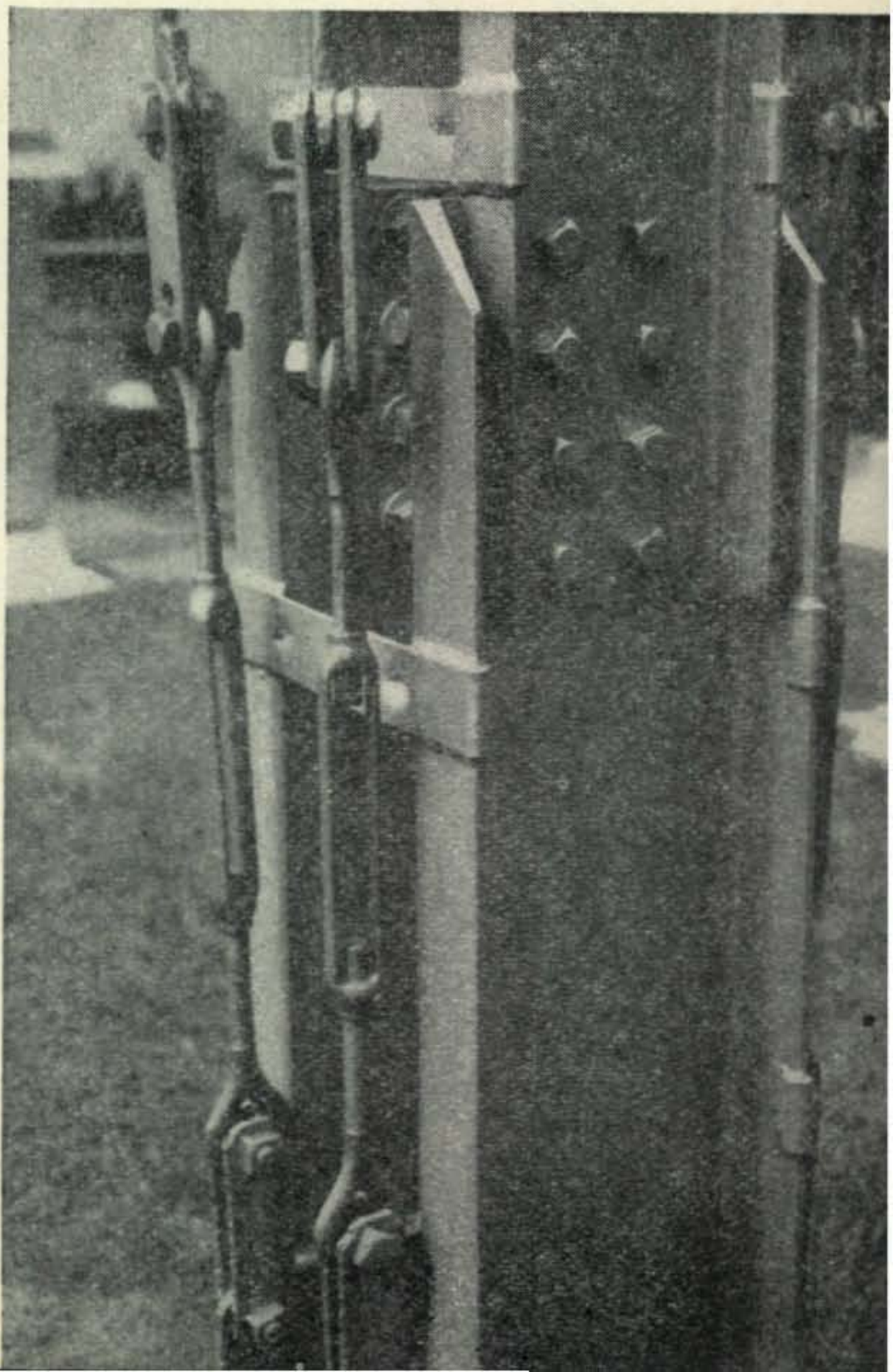
STEEL REQUIRED

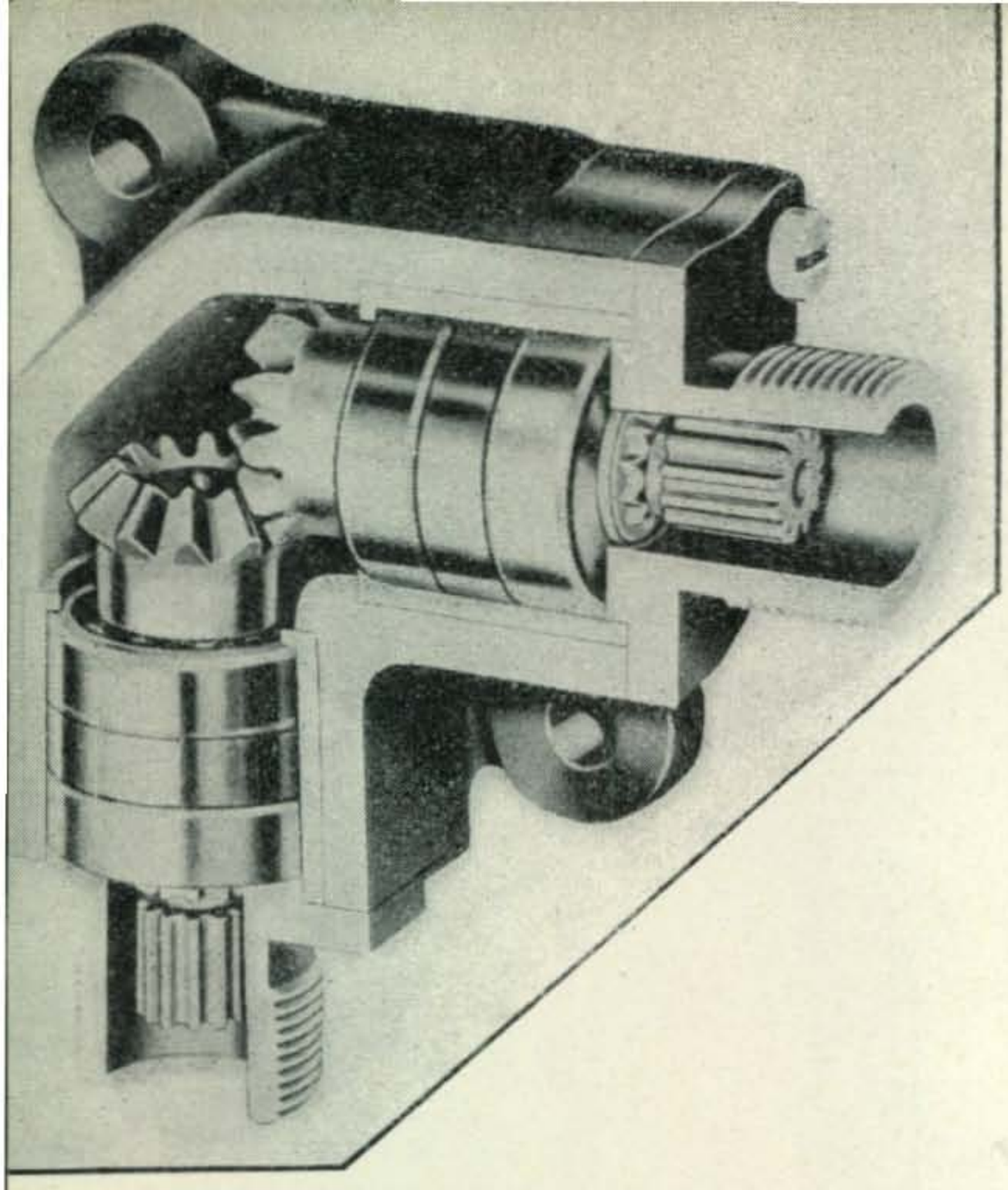
Top Section—	2	5-inch	channels	15 ft.
	2	6 "	"	13 ft. 4 in.
	2	7 "	"	13 ft. 4 in.
	2	8 "	"	13 ft. 4 in.
	2	9 "	"	13 ft. 4 in.
Base Section—	2	12 "	"	11 ft.

When fully assembled, the entire structure should be given a coat of red lead and a top coat of aluminum. This design, or modifications of it, will provide a mast capable of withstanding the severest physical punishment. It is a permanent installation, inasmuch as it would be impractical, if not impossible to salvage the base section. The low per-foot price for all steel construction is a feature of this antenna support.



(Below) Detail of the outrigger lower terminal and the joining of the base and first sections





(Left) Cutaway view of right angle drive which permits use of flexible shafting around sharp turns. (Right) Flexible shafting provided with a crank handle for rotation *(Lear Inc. photographs)*

FLEXIBLE In Amateur

FLEXIBLE SHAFTING has come into its own during the war, and even wider usefulness is indicated when peacetime production gets under way. Commonly used before the war for tuning car radios (and in transmitting power from motor to a dentist's drill), flexible shafting has many new assignments. In amateur radio, pre-war use of this versatile product was largely limited to short lengths of shafting in the form of flexible couplings. It is particularly well suited for experimental work and unusual ham station design. Increased use of flexible shafting in the amateur field seems assured.

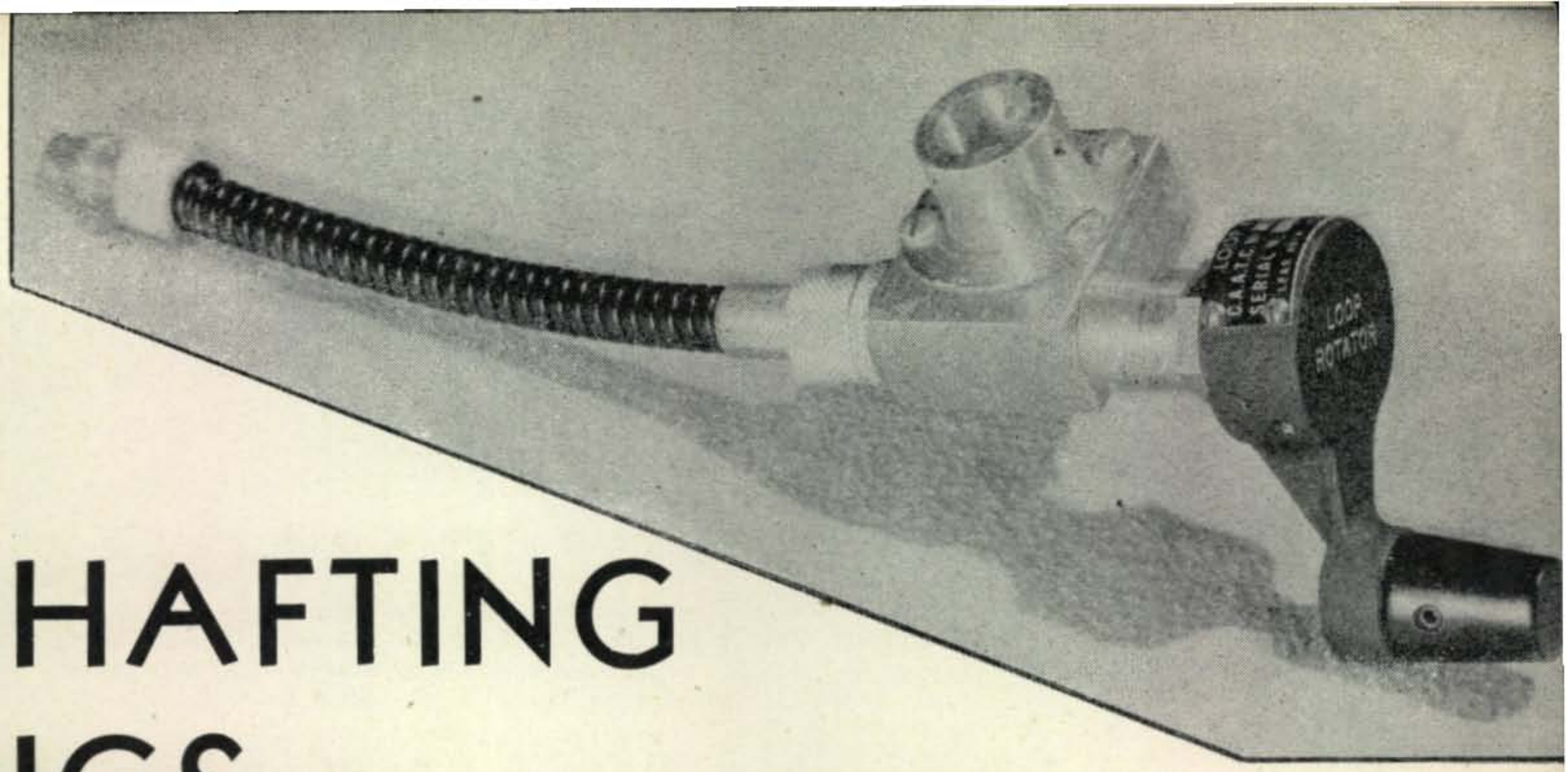
Flexible shafting is usually made of many strands of closely-wrapped wire wound in opposite directions. The greatest care is exercised in manufacturing the shafting so that its flexibility is correctly tight—neither too stiff nor too soft. It must possess the proper deflection under load, as well as the proper tensile strength and elongation properties.

Remote Control

Remote control of radio transmitters seems to be a desideratum in amateur design. This is especially true when the simplicity of certain systems becomes apparent. It is unnecessary to become involved in complicated control circuits to achieve flexibility of a high degree. The newcomer, as well as the more advanced amateur, will find several methods of achieving remote control especially desirable. Because of simplicity and effectiveness, flexible shafting is the most obvious method of remote-controlling the rig.

For amateur work, and especially beginners, the basic consideration of any remote control system is that it does not affect the design requirements of the apparatus (other than advantageously). To put this another way, we would not want to modify a good layout to include remote control. On the contrary, our system should permit the exact opposite. We can make excellent circuit layouts, impractical for direct drive, entirely feasible with remote control. A typical example would be the coil and condenser circuit in a multi-stage transmitter. It is good practice to place coils at right angles to each other, to avoid interaction between their fields. Often this proves impractical because the condenser shaft must emerge from the face of the panel. The simplest remote control device is brought into play at this point, by the use of a small flexible coupling. Commercial couplings have long been available to the amateur in lengths up to 12 inches. The possibility of extending the control of a variable circuit becomes intriguing, especially to anyone who has observed the superior performance obtained under difficult conditions by flexible shafting.

While there is a definite limit to the length of flexible shafts (up to 50 feet when properly applied), their versatility in short lengths more than cover the amateur requirements. Flexible shafts are used in many cases with fittings of various designs attached to the ends and, in most instances, with flexible casings. For shafting in any length longer than a coupling, a case may be required to supply the necessary rigidity.



SHAFTING RIGS

LAWRENCE LeKASHMAN, W2IOP

Round-the-Corner Couplings Contribute to Mechanical Convenience and Efficient Layouts

The size of this outside housing is dependent on the diameter of the shaft. A typical combination is .15″ diameter shaft in a flexible casing with a minimum inside diameter of .17 inch.

Applications

The use of flexible shafting in the amateur radio station falls into three main fields:

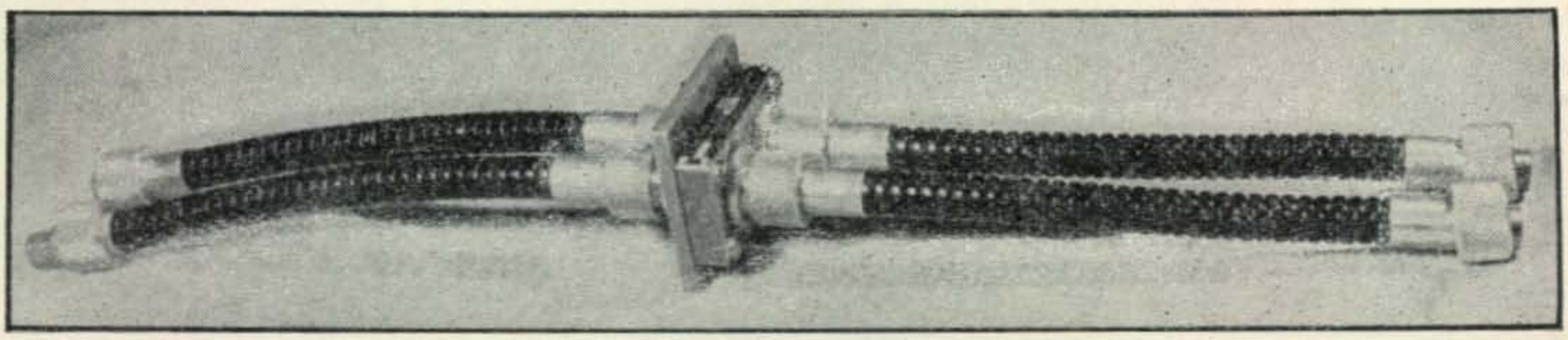
1. Power Drives. To transmit power between points so located with respect to each other that a solid shaft cannot be used, i.e., around corners, at various angles, and in other cases where driving and driven elements are not aligned or must be moved with respect to each other.

2. Remote Controls. To operate parts which must be: *a*—rotated a fraction of a turn, or one or more complete turns; *b*—both rotated and reciprocated.

3. Coupling. To transmit either power or control movement between parts located within the confines of a piece of equipment, as distinguished from the use of flexible shafts for transmitting power or control movement from an externa point.

The different characteristics of flexible shafting are evident in a number of design details. The most important of these considerations are the grade of wire, the multiplicity of layers, number and size of wires in each layer, degree of pitch or lead of wires, and the winding tension. Desirable characteristics have also been imparted to some shafts by heat treatment after winding. For amateur use, the particular type of shaft is not too important. A diameter of around .15″ will prove most easily handled.

Flexible shaft is manufactured in long lengths which are cut to users' requirements. Because of the tension in the flexible shaft wires which make up the shafting, the wires tend to unwind when the shafting is cut. Consequently before cutting, some method must be employed for securing the wires at the points where cuts are to be made. Wherever practicable, shafting should be obtained at exact lengths, to avoid the need of cut-



Flexible shafting, casing, and fittings necessary for remote control of two tuned circuits. The panel feed-through is not essential in most amateur applications [*Lear, Inc. photograph*]

ting. It may be preferable to leave a shaft a little long to avoid cutting.

Cable Cutting

Three methods of securing the wire and cutting employed commercially are as follows:

1. Swaging. The section where the cut is to be made, is compressed in a die. The shafting is then cut or sheared in the center of the swaged section. This method is particularly suited to quantity production.

2. Brazing. With the point at which the cut is to be made as a center, a section of the shafting is brazed while clamped in a special fixture. The shaft is then cut apart with an abrasive wheel.

3. Electric Arc. In this method the shafting is clamped in position on a special electric arc machine which fuses and cuts in one operation.

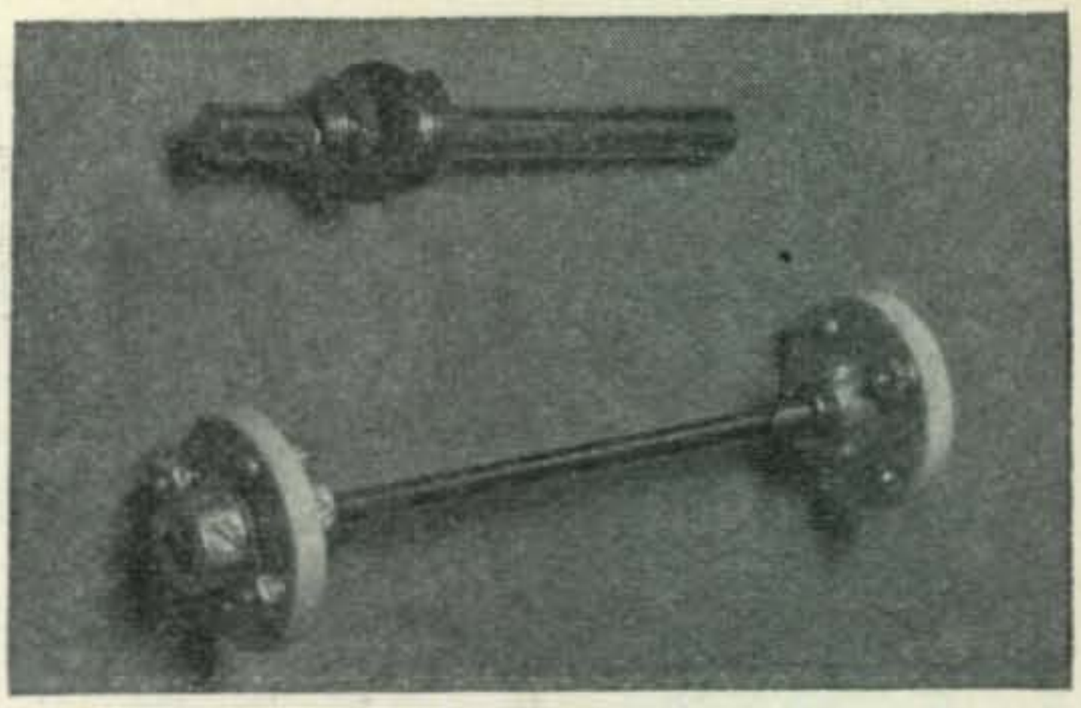
Fittings are attached to the ends of flexible shafts by soldering or swaging. The former method is used where the volume of shafting is not large, as in the ham shack, because it can be done without any special equipment such as presses and dies. When attaching fittings by this procedure, follow these suggestions:

The shaft should fit the hole in the fitting with a minimum clearance, and both the hole and shaft end must be thoroughly tinned. Use a non-corrosive soldering flux and remove the superfluity. Avoid excessive heat which may affect the temper of the shaft wires.

Swaging, which is considered the more desirable method of attaching fittings, requires the use of special machinery not ordinarily available to the amateur. However, a local serviceman or garage specializing in auto radios may be equipped to swage end fittings on the shaft. Swaging is accomplished by placing the fitting over the end of the shaft and pressing together a part of the common section with press and dies.

In the home shop, cutting and fastening flexible shaft is simple to handle if the proper preparations are made. The shafting must be secured in a vise, several inches behind the desired cut. The shafting should be tightly bound with wire in front and behind the intended cut. The excess shaft is then cut off with a hack saw.

The next step is to tin thoroughly the fresh cut section back about an inch or so. The end fitting, which must have the interior tinned, is then soldered to the cut shaft. It is very important that a good soldering job be done. The wire binding placed on the shaft before cutting can now be removed. This wire merely serves as a safety in case the vise grip should slip. (If a case is to be used over the shaft it is important to remember to adjust the case before soldering the end fittings. If this is not done, it will be necessary to start all over again, since the case fit is too snug for the end fittings to pass through.)



Short lengths of flexible shafting formed into flexible couplings are available commercially. Panel feed-through bushings are also standard accessories [*Bud Radio Co. photograph*]

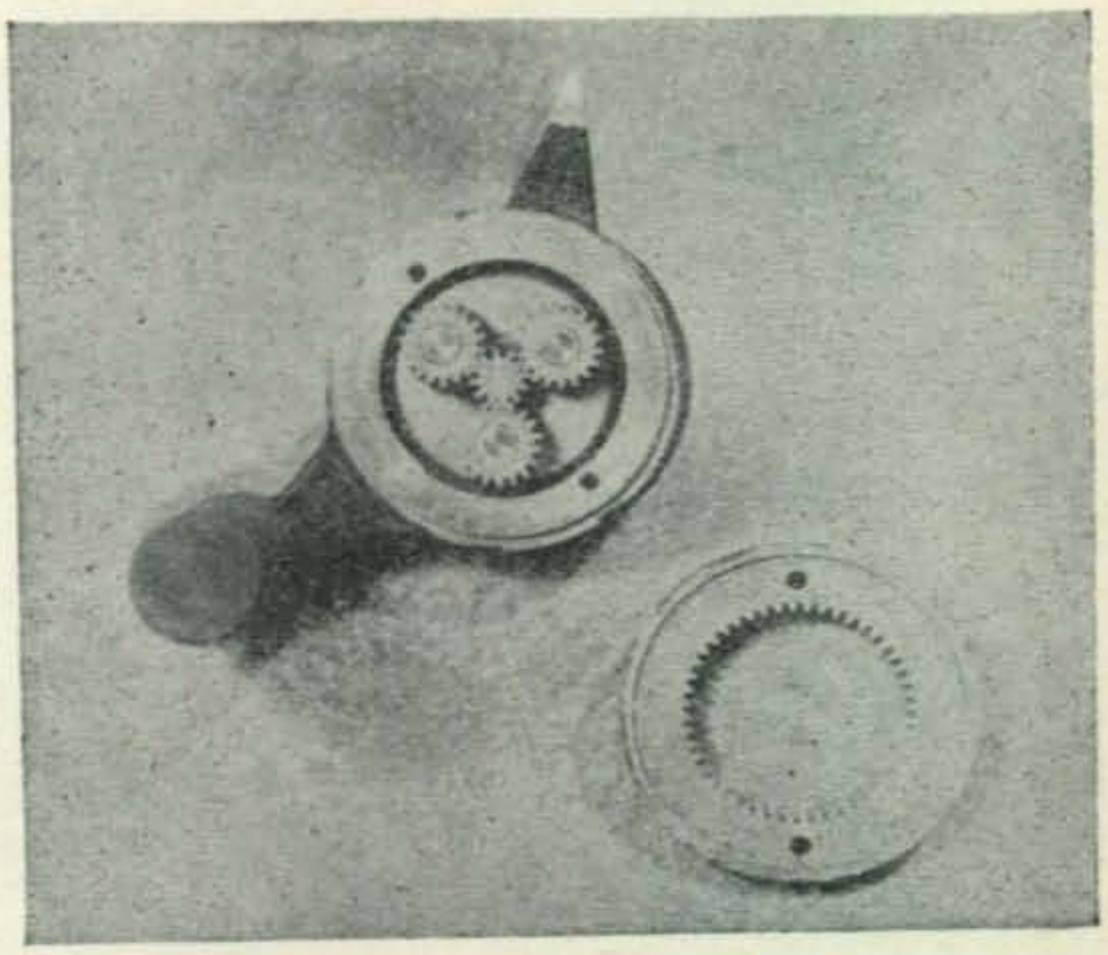
The methods of connecting flexible casings to the housings of the control and controlled members, are as follows: *1.* Insert the bare ends of the casing into holes drilled to receive them in the connected members and fasten with set screws. *2.* By means of fittings of various designs attached to the ends of the casing. The first of these methods is used to some extent for control applications but seldom on power drives. The second arrangement is widely employed for all purposes.

Attaching End Fittings

End fittings can be attached to casings by soldering—the method commonly used on metallic casings. Both the hole and the end of the casing must be thoroughly tinned with non-corrosive flux. Care should be taken to keep the solder from flowing inside the casing. Too much heat should also be avoided so as not to affect the temper of the casing.

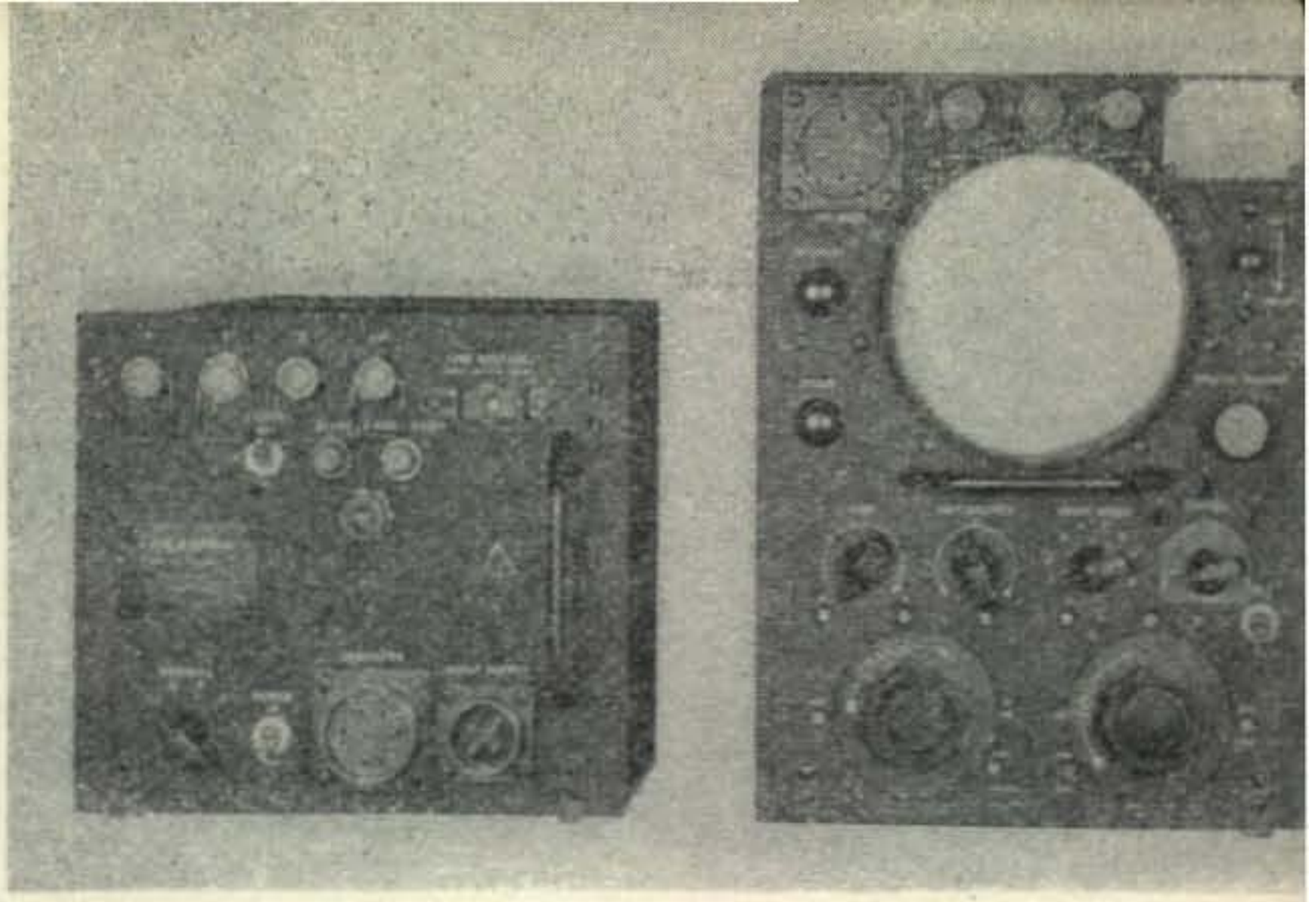
Other methods, not particularly adaptable to most amateur work, include swaging, crimping

[*see page 43*]



Gear mechanism provided to reduce backlash when tuning with flexible shafting [*Lear photograph*]

ON THE BEAM



Loran Type AN/APN-4 airborne receiver (left) and indicator *[U. S. Navy Photo]*

While Loran, Radar and Racon have little direct bearing on amateur radio, they form an important branch in the constantly expanding field of radio, and offer professional possibilities to the Radio Amateur who is in a technically strategic position to operate and service this equipment

ROBERT L. ROD, W2KVY

DURING THE PAST few years, wartime advances in the science of electronics have further simplified the art of navigation to the extent where passengers debarking after long aerial flights no longer marvel at the excellent adherence to posted schedules. Flying across great expanses of water has become a routine experience mainly because the air crew is at all times fully cognizant of its position in space with respect to the earth below.

Whenever either the sun or the stars are visible, a navigator may resort to the centuries-old technique of establishing a position "fix" by noting either the elevation of the sun above the horizon or the configuration of the celestial bodies. Generally most navigators are confident to dispense with these arduous tasks, relying entirely upon dead-reckoning and electronic aids to navigation for their position data.

Before taking off on a long flight, generally an overwater operation, either the navigator or the pilot prepares a "flight plan" which will indicate the magnetic headings it will be necessary to fly to achieve a desired "true course" (projected on the surface of the earth below) under known and predicted wind conditions along the route. The wind, when determining its effects, is treated as a vector quantity possessing both magnitude and direction (measured from true north in a clockwise direction). If the wind direction along the entire planned route is uniform, for example, and is such that it is a perpendicular bisector of the bearing between two map points listed in the flight plan, the heading of the aircraft must be made into the wind in order to achieve a true course. This vectorial problem is solved in flight by means of a small circular computer.

Once the wind problem is solved, the navigator estimates "expected time of arrival" (ETA) at prominent points along the route by determining his ground speed and true course, and combining these figures with the clocked elapsed flying time from a previously observed ground reference or "check" point. The entire problem just described is known as navigation by "dead-reckoning," and for accurate flight visual (or radar) fixes must be made on all available check points. If the wind maintained the same velocity and direction over an entire route, the use of check points and fixes would not be mandatory, but in practice the wind shifts constantly.

Radio Range System

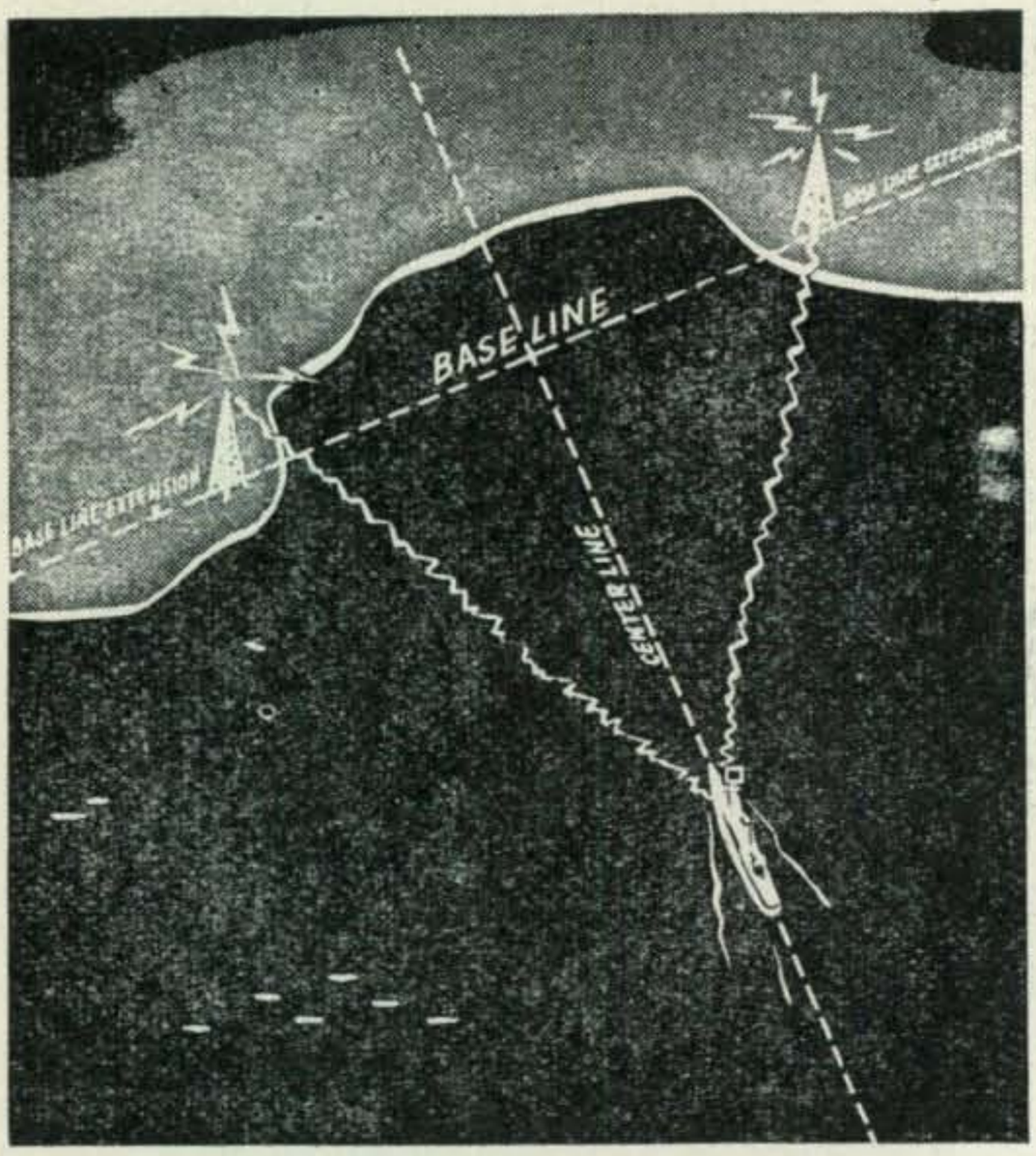
On short overland flights, the services of a navigator are not required, and instead the pilot determines his own navigation requirements while relying heavily upon the large network of Radio Range stations for "directions." These ranges consist in effect of two narrow overlapping radio beams laid down on the assigned cross-country flying routes. A pilot, flying down the overlapping equal-signal-strength line of the two beams, audibly detects a continuous a-f note of approximately 1,000 cycles in the headphones of the range receiver. Deviations from this center line, or course, produce the same note with varying amplitude which is being keyed either as the Morse letters N or A, depending upon the direction of deviation from the course. Since these two Morse letters are complementary (— · and · —), the center line representing equal signal strength from each beam produces a steady note indicating correct course. This system of navigation is accurate and requires little in the way of airborne

receiving equipment but it suffers from an inability to fix definitely the plane's position and from some inaccuracies due to signals reflected from natural ground objects of large areas.

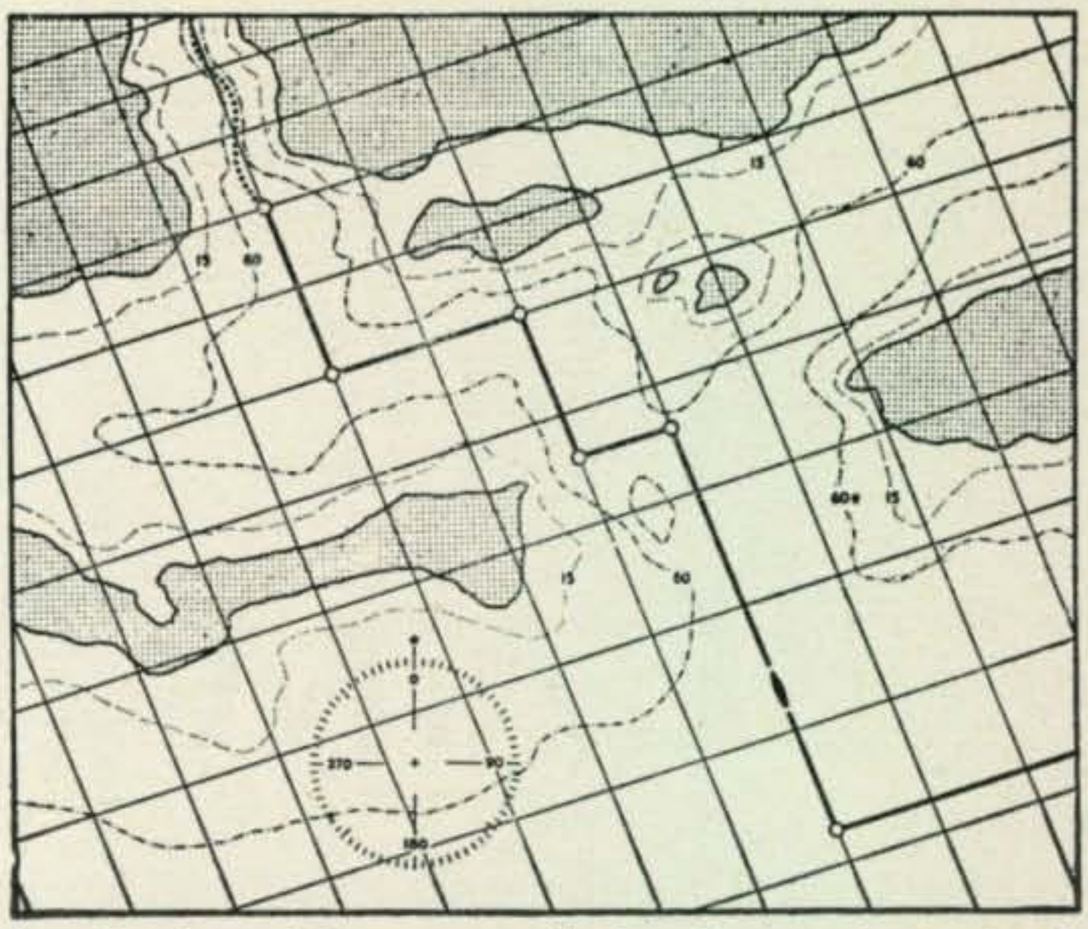
Radio Direction Finder

Most aircraft in commercial or military service are also equipped with a loop direction-finding receiver, or radio compass, which allows the pilot to obtain a direct bearing on any station operating within certain frequency ranges. This type of installation is valuable as it permits a fix to be made in flight by noting the intersection of the reciprocals of bearings made on two or more ground stations.

Many large aircraft employ in addition a VHF transmitter-receiver installation for use in obtaining landing instructions at the larger airports, and in conjunction with this type of installation a number of ground VHF Direction-Finding (D-F) stations have been established. A pilot desiring a position or fix may obtain the necessary information by "calling-down" to the nearest ground installation for a D-F fix, after which he leaves the VHF transmitter on (usually tone modulated for this purpose) for several minutes. The available ground VHF D-F stations within radio range will then reverse the procedure described previously for the airborne loop direction-finding receiver, and a fix of the plane's position in space will be radioed back to the pilot. Two or more D-F stations must be able to monitor the aircraft in order to furnish a fix. The system is advantageous as it offers an additional method of establishing a position, but as yet the VHF D-F



Simultaneous pulses transmitted from two stations arrive at the same instant at any point on the center line. Thus when the time difference is zero, the ship is somewhere on the center line [*U. S. Navy Photo*]



Application of Loran to piloting in entering a land-locked harbor [*U. S. Navy Photo*]

stations have not been installed for a complete coverage throughout the country.

The radio navigational systems just described have been supplemented in many new installations by three wartime developments, all of which strive to satisfy the new concept of electronic navigation which calls for quick fixing of position with respect to the earth without resorting to spoken communication (and if possible without resorting to the use of ground equipment).

The Loran System

The first to be described, an outgrowth of wartime research, is the amazing and valuable LORAN, the LOng RAnge Navigation system, which distinguished itself in both the maritime and aeronautical services. The principles of Loran may be described by noting *Fig. 1*, in which two high-powered pulse transmitters are shown several hundred miles apart on a coastline at points *a* and *b*. For explanatory purposes, assume both transmitters are emitting synchronized pulses on the same frequency in unison. A receiver tuned to the transmitters' frequency will, when located at point *P*, the perpendicular bisector of the theoretical line between the two stations, receives both pulses simultaneously due to equal r-f transit times.

If the receiver is moved from point *P* to point *A*, the pulse from station *a* will arrive at the receiver a definite number of microseconds (for example 263 microseconds) ahead of the pulse from station *b*. A difference of 263 microseconds between receipt of these two pulses also exists anywhere along the hyperbola *A A′ A″* (a hyperbola being defined as a line of constant time difference). Similarly, a hyperbola representing a difference of 263 microseconds may be drawn through points *B B′ B″*, where $aA = bB$. Therefore, a full family of hyperbolas may be drawn on a map of the area anywhere within radio range of both stations for any desired differences in

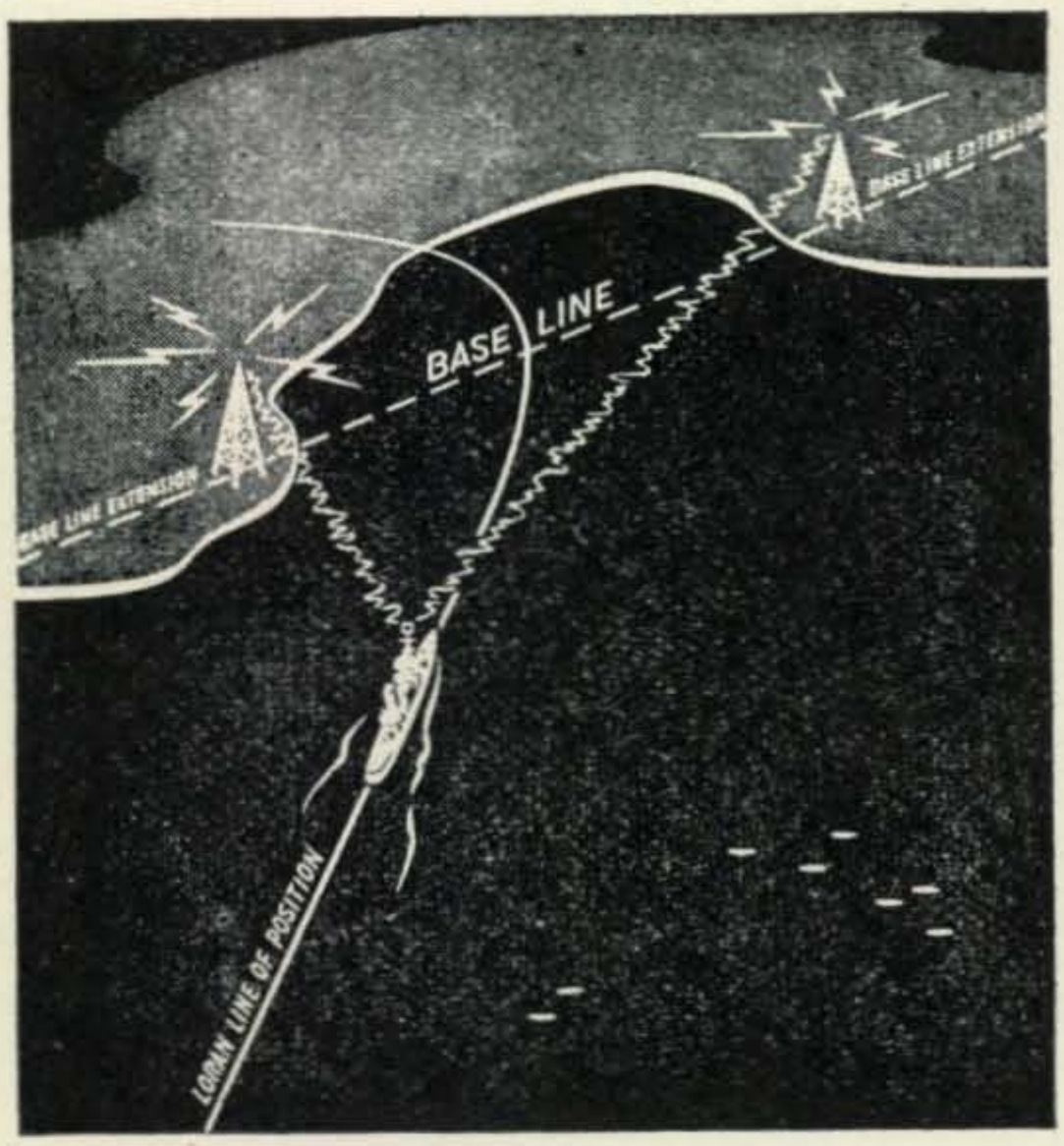
transit times. A receiver, which is capable of measuring this time difference between receipt of the pulses, when located anywhere in the area, may be established on either one or the other of two "lines of position" (LOP). In practice, if both transmitters were pulsed simultaneously the ambiguity between an LOP on hyperbola *A A' A''*, for example, and hyperbola *B B' B''* would prove confusing to the operator who could not determine his true LOP. This ambiguity is resolved in practice by delaying the pulsed output of one of the two transmitters over the output of the other by a fixed time considerably greater than the r-f transit time between the two stations.

The control station is referred to as the "master," while the station delaying its pulse is termed the "slave." In *Fig. 1*, we will label station *a* the master and *b* the slave. Therefore, with a sufficient delay time inserted between the pulsing of slave and master transmitters, the pulse from station *a* will always arrive at any receiver location within radio range of both stations prior to the pulse from station *b*. No ambiguity can now exist as to on which side of the center line (dividing the distance between stations) the receiver is located.

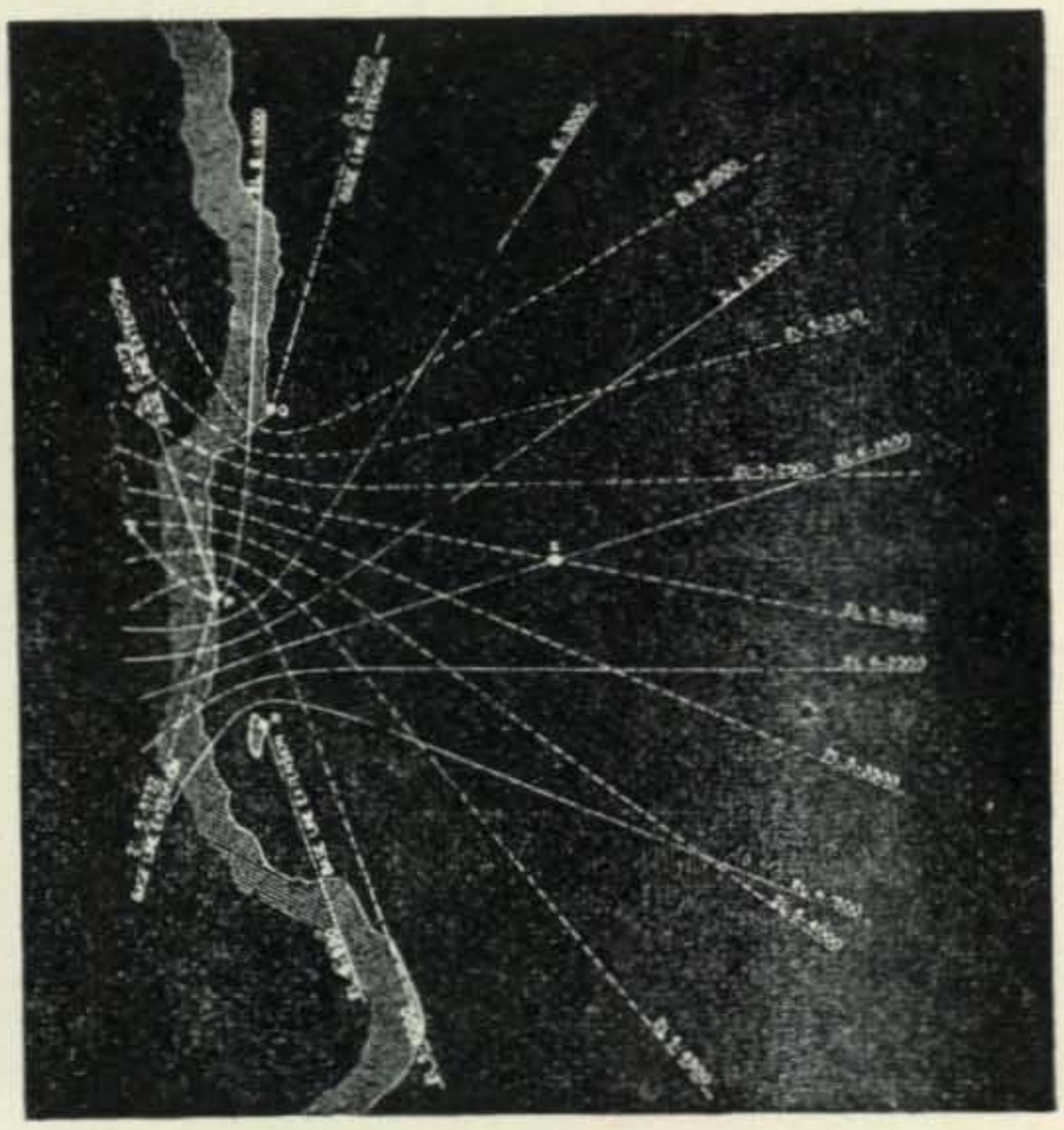
Since a fix is a bisection of two or more LOPs, two pairs of Loran transmitters must be used to locate a receiver anywhere in space. In practice, two or more Loran pairs give complete coverage in all service areas, and the charts provided with the receivers are over-printed maps having the hyperbola families for each pair colored for easy identification.

The Loran picture is completed with a description of the combination receiver-indicator. Both the airborne and shipborne versions of the Loran receiver-indicator utilize a modified A-Scan sweep (usually on a 5" CRT), as shown in *Fig. 2a* in which the lower trace on the CRT is in reality a continuation of the upper trace "broken" in half, and displaced down and to the left for the purpose of achieving a longer sweep without increasing the size of the cathode-ray tube itself. A "pedestal" is fixed at the left of the upper trace, while a movable pedestal (adjusted by the operator using two knobs, a "fine" and a "coarse" adjuster respectively) is placed so as to slide along the lower trace at will. The pulses from the master and slave stations are placed on these traces for observation and time-difference analysis. Synchronism between the pulse recurrence frequency of the transmitter pair and the indicator sweep, which is necessary in order to make the received pulses stand still, is obtained by use of a standard-frequency generator and a series of counting-down multivibrators within the receiver-indicator. A slight amount of deviation from this synchronism is available to the Loran operator who utilizes this feature to move effectively the master pulse (as well as the slave pulse) until the former is placed atop the fixed pedestal on the upper trace. In this position, the slave pulse falls somewhere along the lower trace.

The time, in microseconds, along the sweep from the leading edge of the master pulse to the leading edge of the slave pulse is the time difference between the arrival of the pulses from stations *a* and *b*. In order to measure this time difference, the receiver-indicator electronically measures not the actual distance between leading edges of the two pulses, but rather the time in-



A ship or plane receiving a pulse from one station earlier than from the other is on the line of position shown. The line of time difference is a hyperbola around the nearer station [*U. S. Navy Photo*]



Position X is obtained by reading on the ship's Loran receiver the time difference of signals between master station P and slave station Q, then the time difference for stations P and R [*U. S. Navy Photo*]

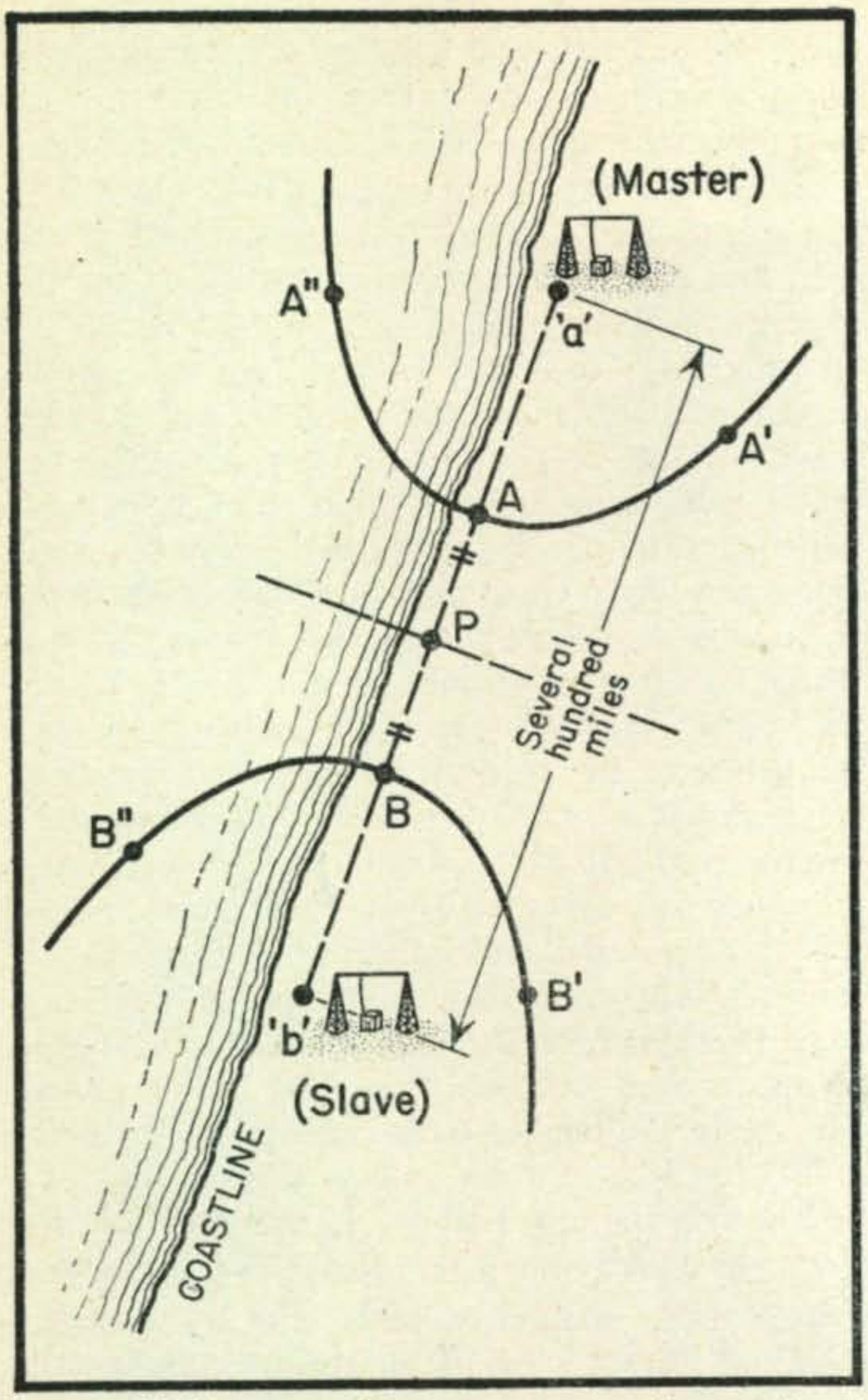


Fig. 1. High-powered transmitters are shown placed several hundred miles apart on a coastline

terval along the sweep between the two pedestals when the pulses are correctly positioned atop the pedestals.

Interpretation

When the correct pulses are atop their respective pedestals (the various system of time delays are arranged so that the operator may never place the slave pulse atop the upper pedestal and secure the master pulse on top of the lower pedestal), the sweeps are expanded to show only the tops of the pedestals and the mounted pulses. This condition is illustrated in *Fig. 2b* where the operator adjusts the "fine" control to secure the slave pulse at precisely the same relative position on the lower trace as the master pulse on the upper pedestal. The operator matches the leading edges of both pulses by small horizontal movements of the slave pulse along the lower trace. He further increases the alignment accuracy by switching to a new presentation wherein both traces are combined (*Fig. 2c*), and where both pulses may be precisely aligned for leading-edge coincidence.

Since the slave and master pulses usually are of different amplitude (and matching the leading edges becomes difficult under such conditions), a novel gain control and balancing system is incorporated into the receiver-indicator which provides separate receiver gain control settings for both pulses. In this final condition of alignment, the pedestals are spaced a distance from one another, measured from leading edges, equal to the distance, again from leading edges, of the slave pulse from the master pulse. To translate this distance into time, the operator switches through another almost identical set of sweep speeds in which the slave and master pulses have been omitted only to be replaced with marker pulses interspersed by a series of timing pips. By merely counting up the timing pips between marker pulses, the operator is supplied with a numerical figure representing an LOP which may be located on the Loran chart. One of the hyperbolas will be labeled along its length by a time difference corresponding to the figure obtained by the operator from the above procedure. In most instances interpolation between two hyperbolas (labeled in "round" numbers) is necessary to achieve accuracy.

To obtain the desired fix, the operator is required to establish a second LOP by the selection of a second pair of Loran transmitters. Once this reading is achieved it is combined with the first

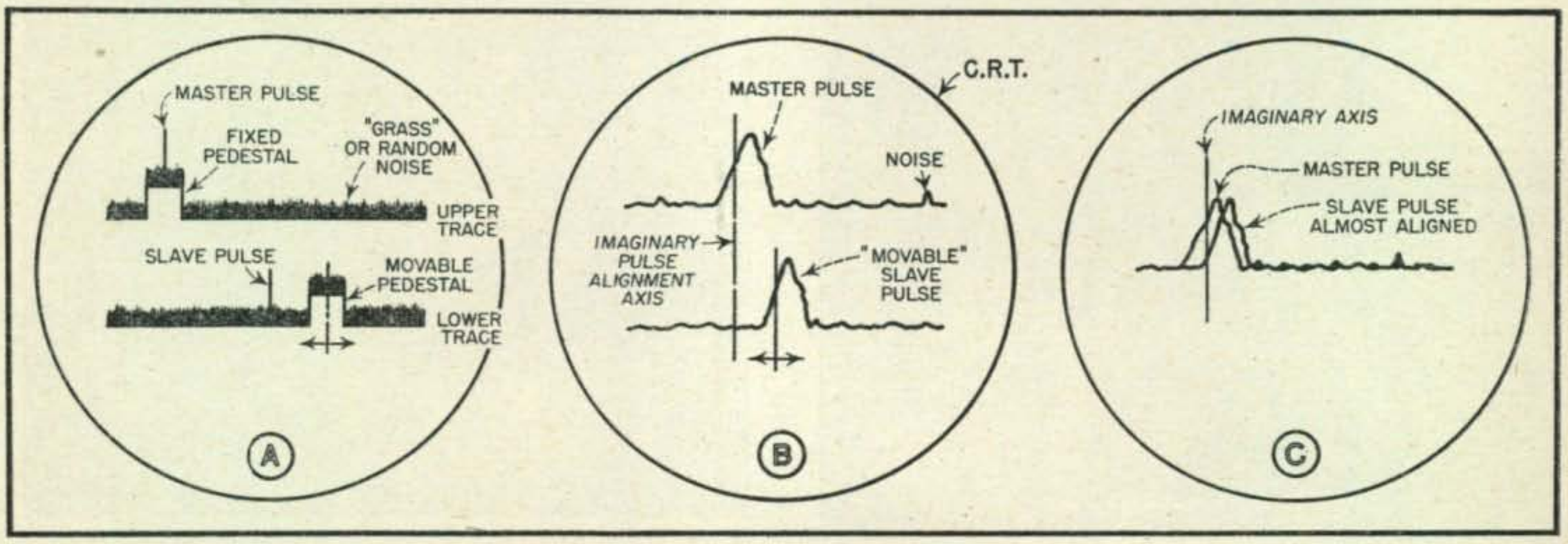


Fig. 2. (a) The master pulse is correctly placed atop the fixed pedestal, but the movable pedestal must be under the slave pulse before calibration can begin (b) Each sweep is in reality the top of a pedestal (c) Both sweeps combined. The individual pulse amplitudes may be controlled by a balancing system to facilitate perfect alignment of both the master and slave pulses

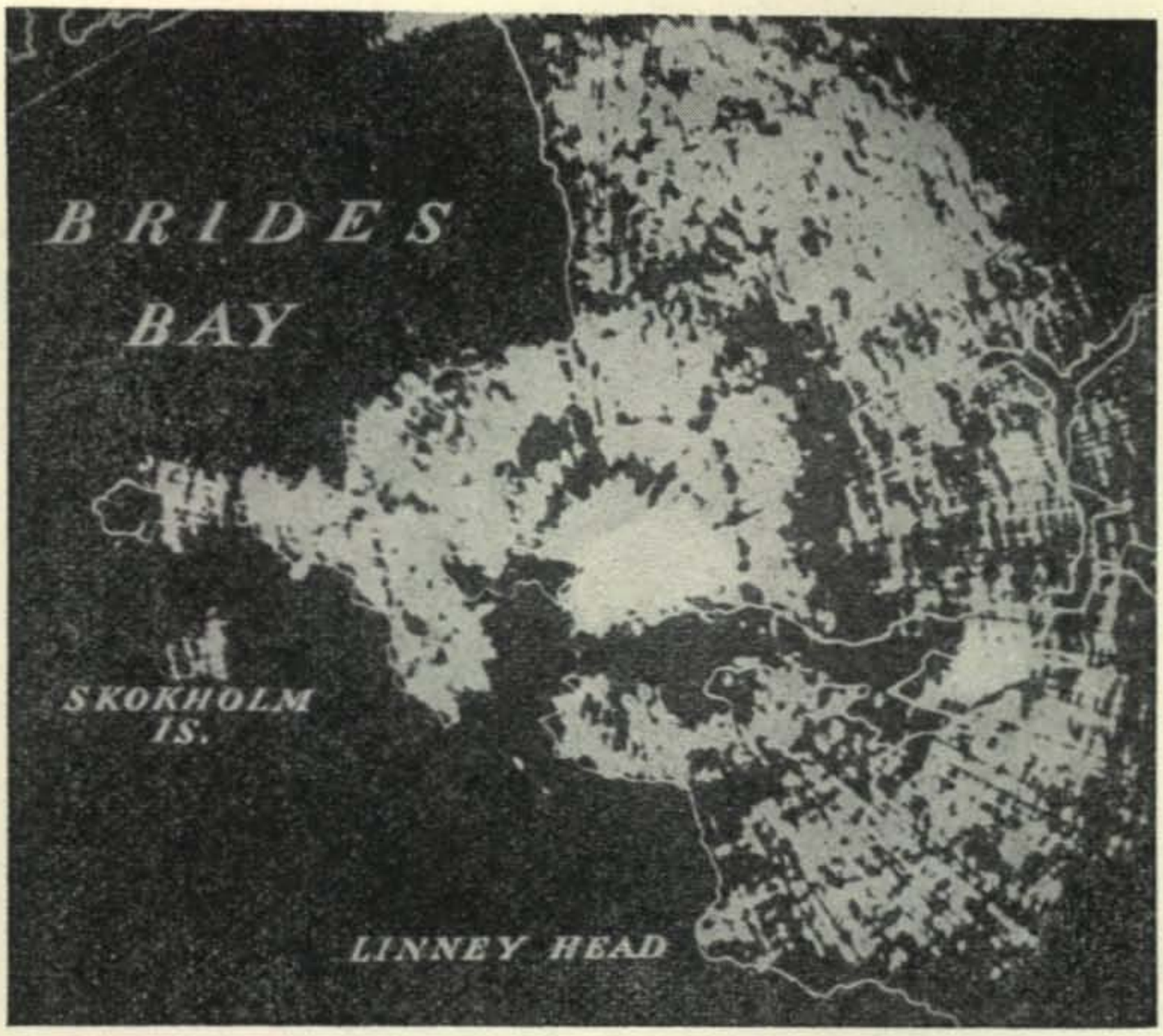


Fig. 3. A PPI 'scope photo made from an airborne search radar, showing the south-west tip of Wales [*British Official Photo*]

LOP to locate the receiver in space. Loran pairs are identified to the operator by variations either in frequency or pulse recurrence frequency. The correct data for each pair is conveniently posted on the Loran charts, and the receiver incorporates simple switching features enabling rapid switch from one pair to another. The entire Loran procedure for obtaining a fix can be performed, after several hours training, in two or three minutes.

At the low frequencies now used in Loran work, the effective daytime range (of the usual ground wave) is around 500 miles, whereas night sky-wave reflections increase the range to approximately 1,000 miles. Corrections are indicated on the Loran charts for readings obtained from sky-wave pulses, and skilled operators soon are able to distinguish between ground waves and sky-waves by the varying amplitudes of the pulses of the latter type.

The charts used in conjunction with Loran, are rather large, and due to the extreme attention that this type of navigation requires, an additional member of an aircrew is necessary for operation. Loran is currently used for overwater flying with ground stations located along both coasts. In its present state, Loran finds little use for overland operations, where only simplified navigational techniques and a small crew are essential.

Radar Search Systems

Shorter over-water flights are successfully utilizing lightweight airborne centimeter radar search equipments for "observing" prominent land demarcations at ranges of up to a hundred miles or so. By comparing the 'scope presentation, on such a set with either terrain maps or previously executed mosaics of a series of 'scope pictures made over the same route at some pre-

[*see page 41*]

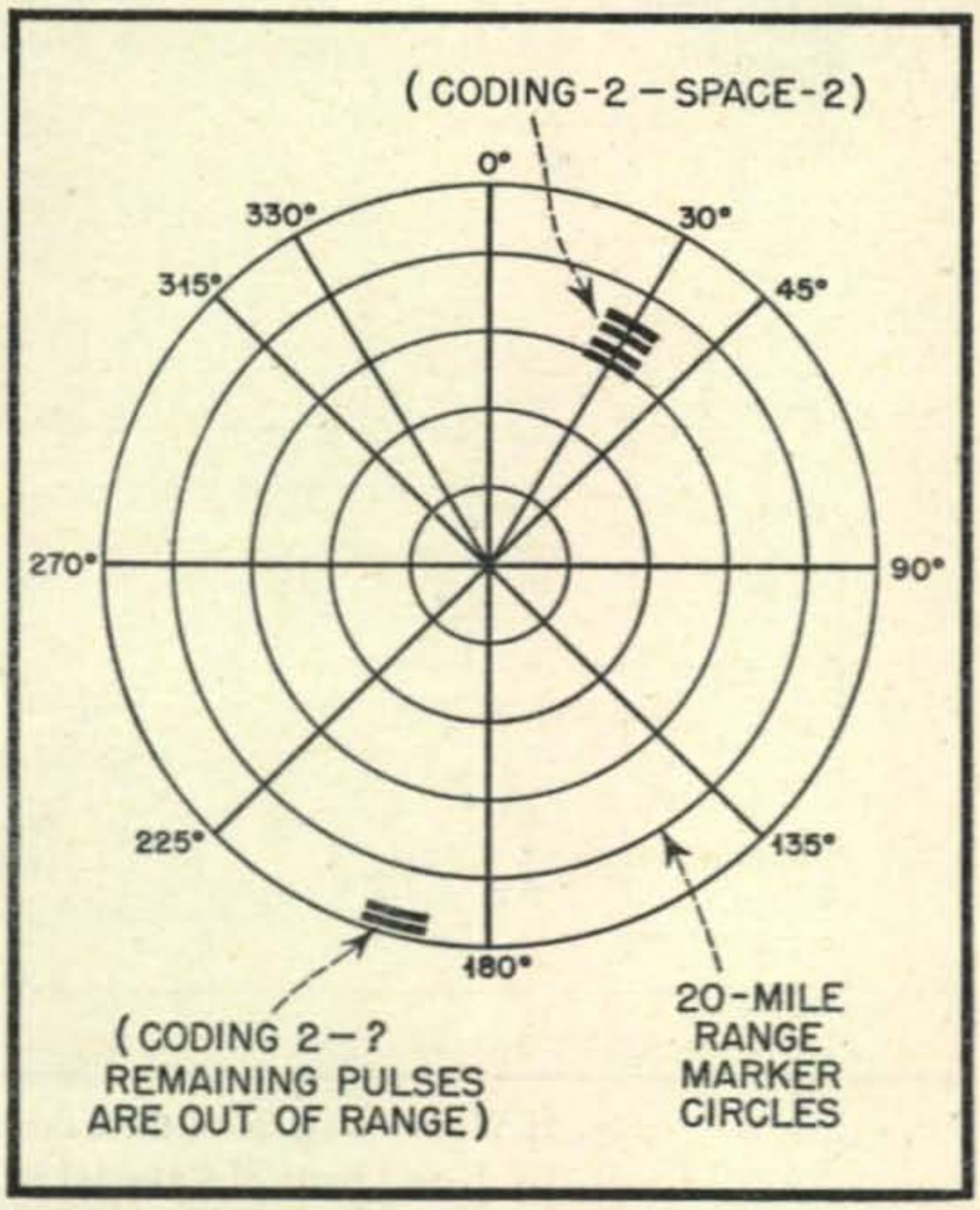


Fig. 4. Radio beacon (racon) signals as observed on a PPI with a sweep length of 100 miles

HIGH OUTPUT TRANSMITTER-RECEIVER

PUTTING THE 6L6 TO WORK ON 144 MEGACYCLES

B. W. SOUTHWELL, W60JW

THE TRANSMITTER-RECEIVER herein described utilizes a 6L6 oscillator and a 6C5 super-regenerative detector. The transmitter is tuned with a screw-driver adjusted trimmer in the tank circuit, which makes it a desirable fixed-frequency rig, as the tendency for the tuning capacitor to change capacity due to vibration is practically nil.

Circuit diagram *Fig. 1*, outlines the complete transmitter-receiver. Coils L_1 and L_4 may have to be pulled apart to hit the 144-148-megacycle band. All r-f leads should be as short as possible, and components rigidly mounted for better stability.

Circuit Details

The 3-pole double-throw switch, in the transmit position connects the 6C5-6F6 tube combination (as a two-stage speech amplifier) to the 6L6

[*see page 39*]

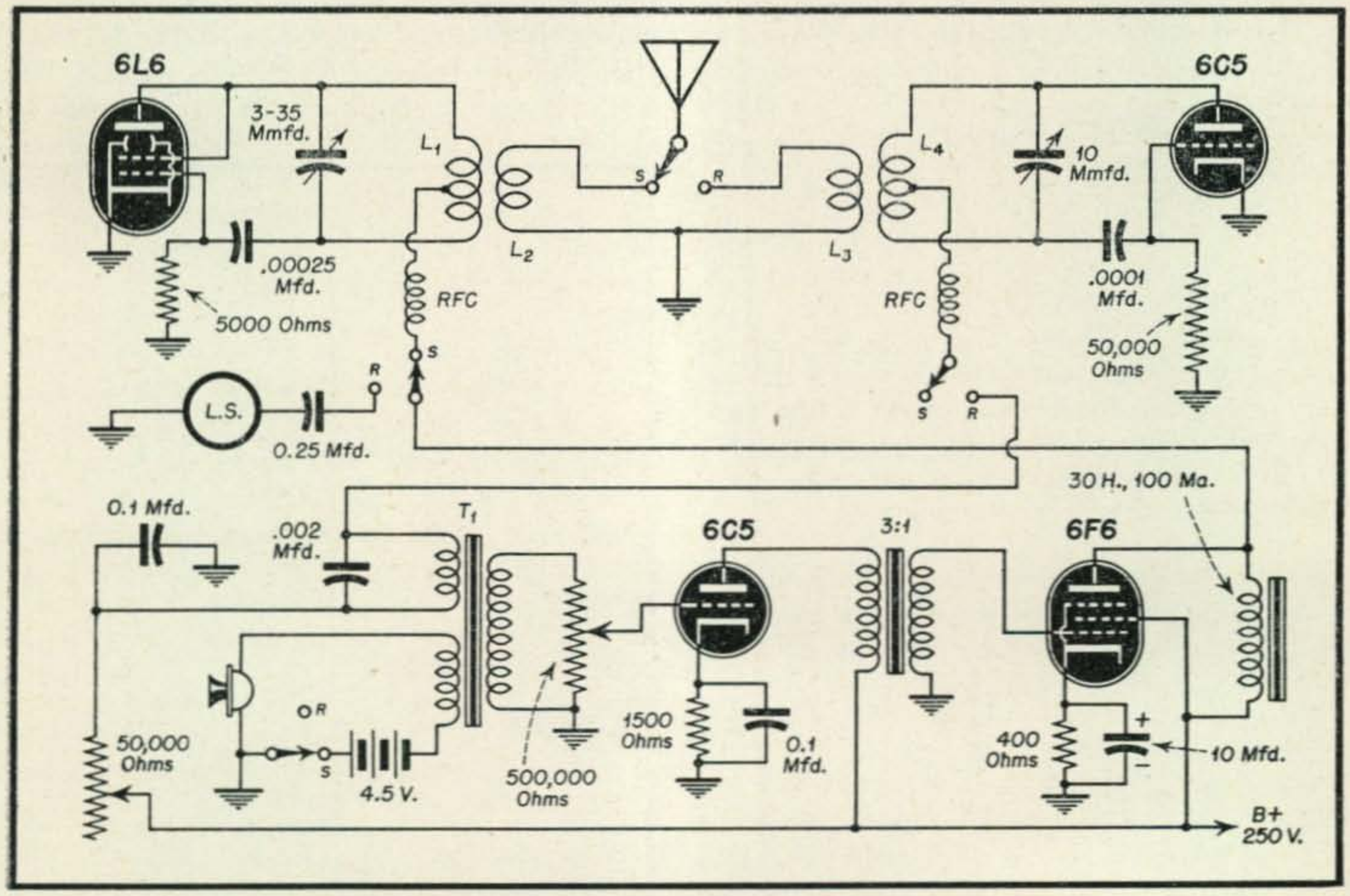


Fig. 1. Wiring diagram of the transmitter-receiver. Inductors are as follows:
L_1, L_4—3 turns #14 enamel ½" dia. 1¼" long
L_2, L_3—2 turns insulated hookup wire around centers of L_1 and L_4
RFC—See Fig. 3
T_1—3-winding midget audio transformer

RADIO AMATEUR'S WORKSHEET

No. 8. POTENTIOMETERS; MULTI-PHASE COMMUNICATION

POTENTIOMETERS

IN *Fig. 1* IS REPRESENTED a potentiometer and its characteristic impedance looking into the input terminals. Let X represent percent of total movement of the slider from the minimum position and Z the resistance at any setting. Of course the rheostat or potentiometer might have had a tapered characteristic as well as a linear one.

Presume a fixed resistor of value K to be shunted from the slider of the potentiometer to either end terminal. This is illustrated in *Fig. 2*.

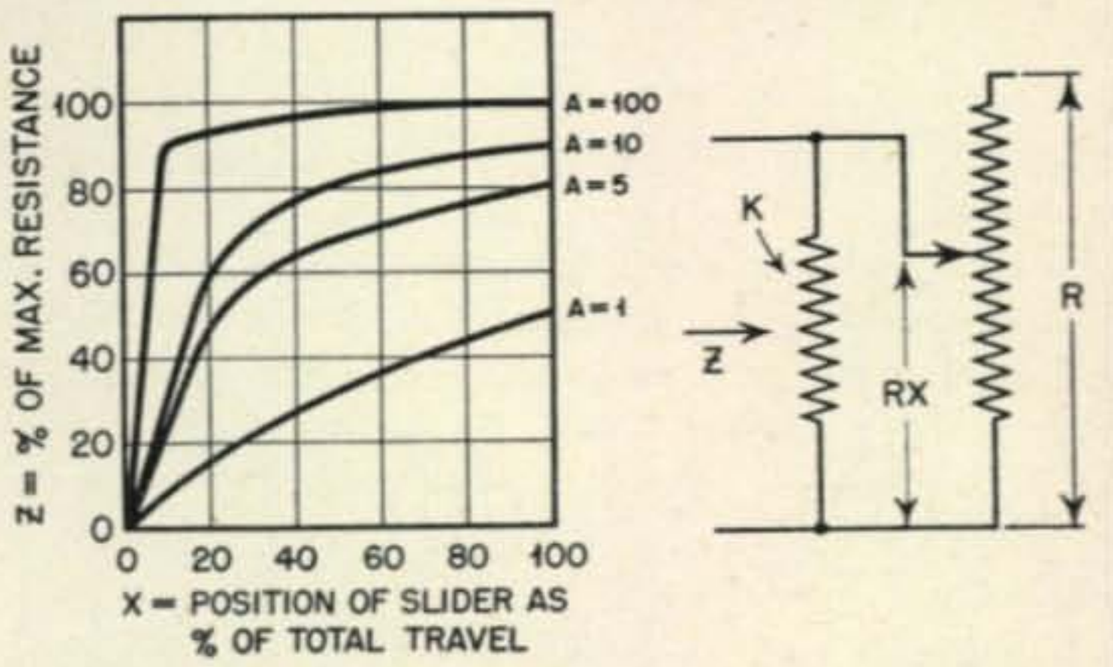


Figure 2

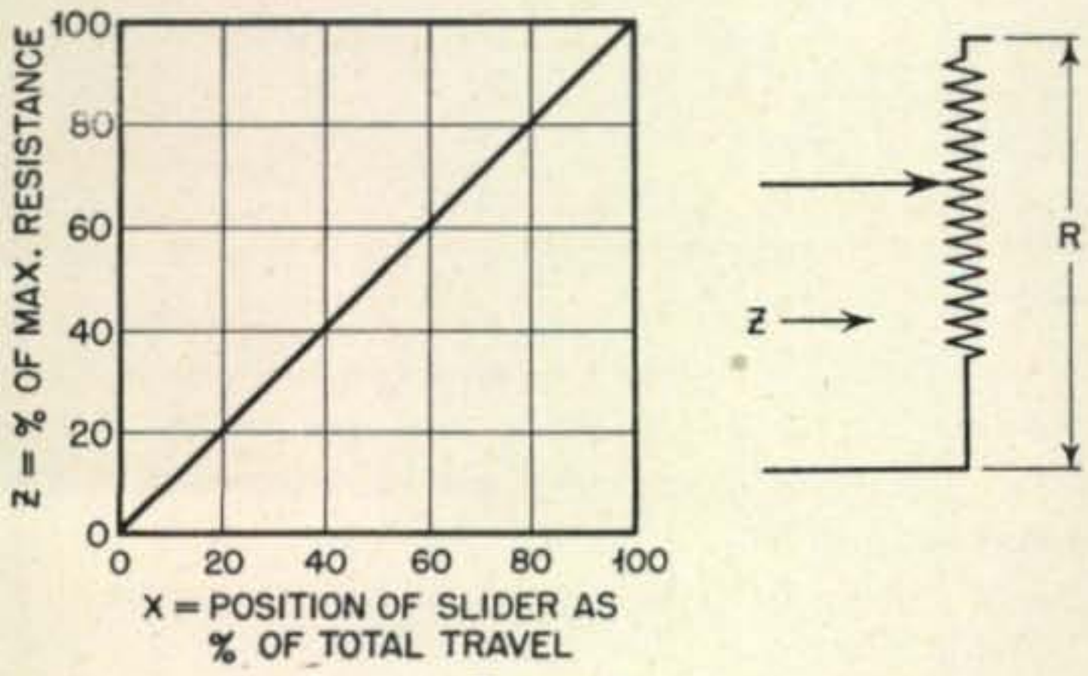


Figure 1

When two resistors are connected in multiple (or parallel) the effective resistance of the combination is equal to their product divided by their sum. Whence for the condition of *Fig. 2:*

$$Z = \frac{KRX}{K + RX}$$

Substituting:

$$A = \frac{R}{K}$$

Yields:

$$Z = \left(\frac{AX}{1 + AK}\right)K$$

It is immediately evident that the ratio of the variable to the fixed resistor determines the shape of the characteristic curve. Likewise it is evident that the value of the fixed resistor for large values of A determines the total resistance Z. If a maximum value for Z of 1000 ohms is desired, then by substitution in the above formula we can find K. For a characteristic such as that for $A = 10$, we find $K = 1100$ ohms. Obviously this arrangement might be used with a tapered variable potentiometer to modify the degree of taper. The degree of modification of the taper can be determined by multiplying the appropriate values of the setting of the tapered potentiometer by the approximate ordinate of *Fig. 2*. For this purpose the appropriate abscissa of *Fig. 2* should be considered as percentage of total resistance rather than percentage of slider travel. Such combinations of resistance are frequently used to change compensations in radio receivers and phonographs.

MULTI-PHASE COMMUNICATION

THERE HAVE APPEARED in the technical press of the past few years several references to multiple phase communication—particularly three-phase broadcasting. In these systems modulation was accomplished by varying the phase of one component in a three-phase circuit. An outstanding advantage of this type of modulation was improved efficiency which is of considerable importance in high-power broadcasting where the power bill is an important item of operating cost. Three-phase modulation was

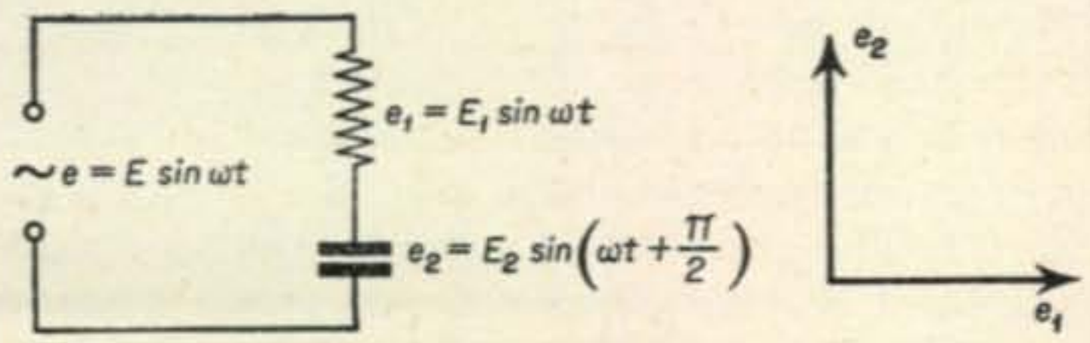


Figure 3

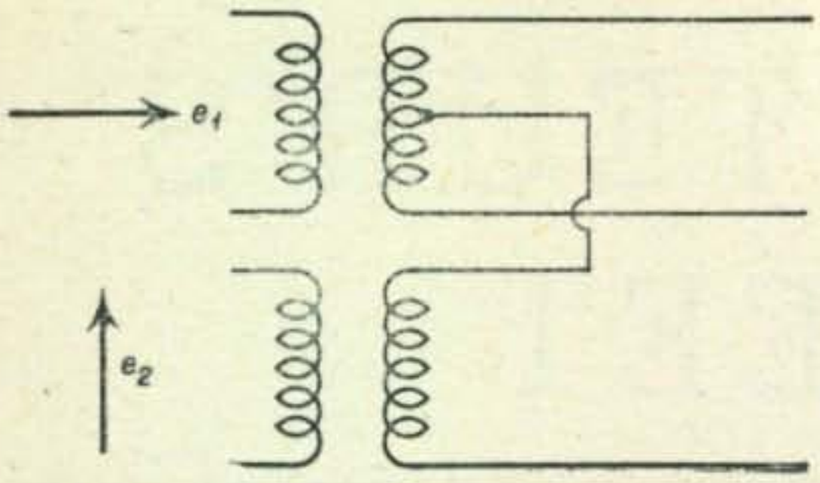


Figure 4

never generally adapted because of the complication of the circuits involved, but this objection may in time be removed; hence we may hear more of this type of communication in the future. It is worthwhile to investigate briefly some of the better known principles of three-phase communication.

If a voltage $e = E \sin \omega t$ is impressed across an impedance consisting of a resistance and a capacitance in series, the voltage across each

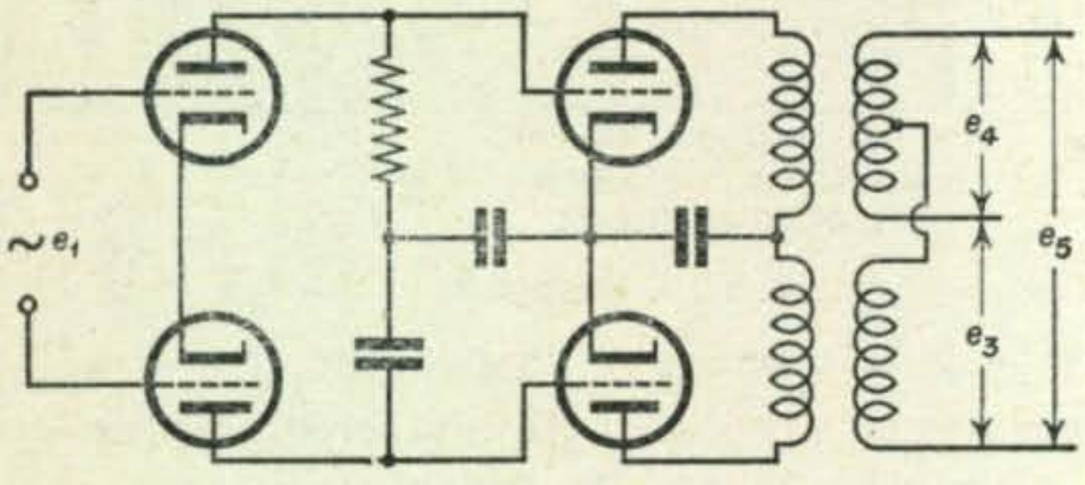


Figure 5

component of the impedance will differ in phase by $\pi/2$ radians. This of course assumes zero power loss in the capacitor and no distributed capacitance in the resistor. If, as in *Fig. 3*—

$$R = \frac{1}{\omega c}$$

the two voltages will be equal in magnitude.

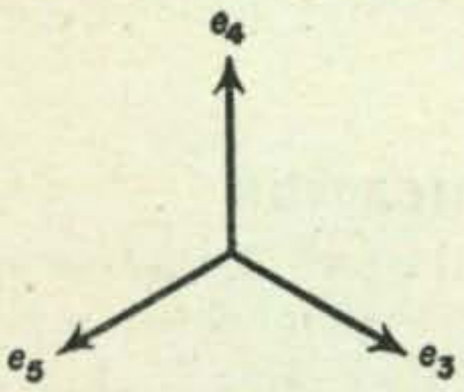


Figure 6

If the two quadrature voltages thus produced are applied to a Scott connected transformer, three voltages differing in phase by $2\pi/3$ radians will result. The transformation ratios of the Scott connected transformer will be

$$\frac{1}{\sqrt{3/2}}$$

if equal three-phase voltages are to result. A Scott connected transformer is shown in *Fig. 4*.

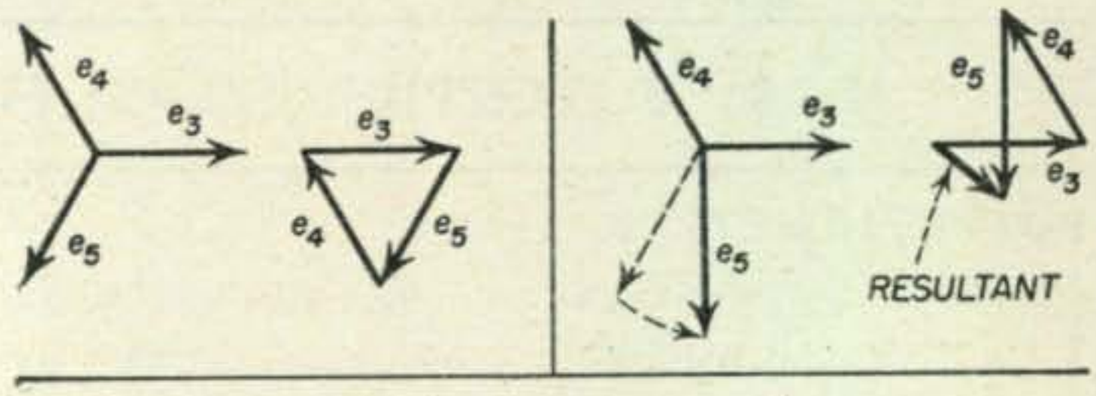
How the circuits of *Figs. 3* and *4* may be combined in a simple two-tube single-stage amplifier, or in a four-tube two-stage amplifier is shown in *Fig. 5*. The three equal output voltages would bear the following relations:

$$e_3 = E \sin \omega t$$

$$e_4 = E \sin \left(\omega t + \frac{2\pi}{3} \right)$$

$$e_5 = E \sin \left(\omega t - \frac{2\pi}{3} \right)$$

This is shown vectorally in *Fig. 6*. It is significant that if the three voltages of *Fig. 6* are added vectorially, the result will be zero. There-



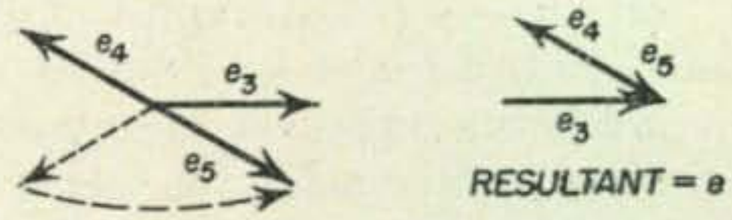


Figure 7

fore if these voltages had been applied to identical transmitting antennas located at the same spot, the resultant radiated field would also be zero. If, however, the phase of one voltage is changed they no longer add up to zero and a definite field would result. The greater the change in phase of the one vector the greater the radiated field. Consequently, if the amplitude of a modulating voltage could be made to control the phase of one vector, then the magnitude of the radiated field will be proportional to the magnitude of the modulating voltage. This is the basic principle of three-phase broadcasting somewhat simplified. A future worksheet will deal in more detail with this type of broadcasting.

How changing the phase of one voltage produces a resultant vector, the magnitude of which is dependent on the phase excursion, is shown in *Fig. 7*, while *Fig. 8* illustrates some simple types of three-phase filter circuits. One filter is of the high-pass variety, another of the low-pass type and the third is a band-pass filter.

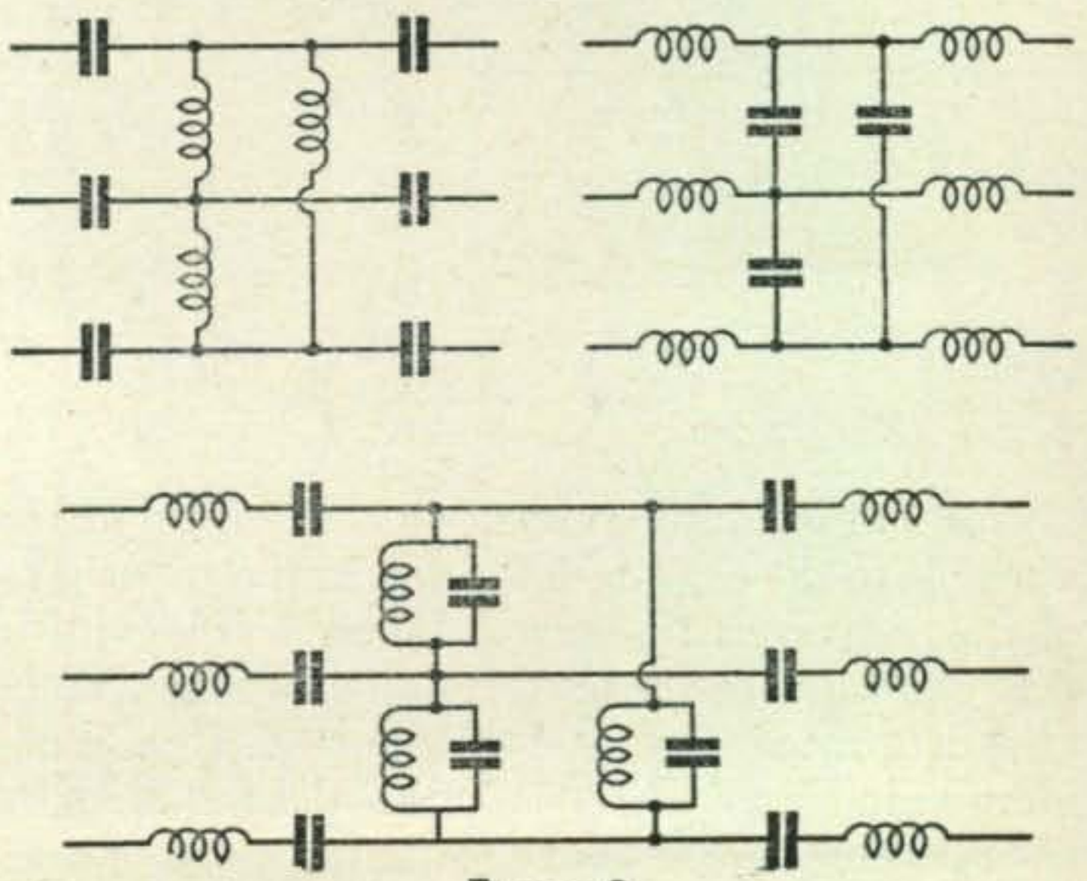


Figure 8

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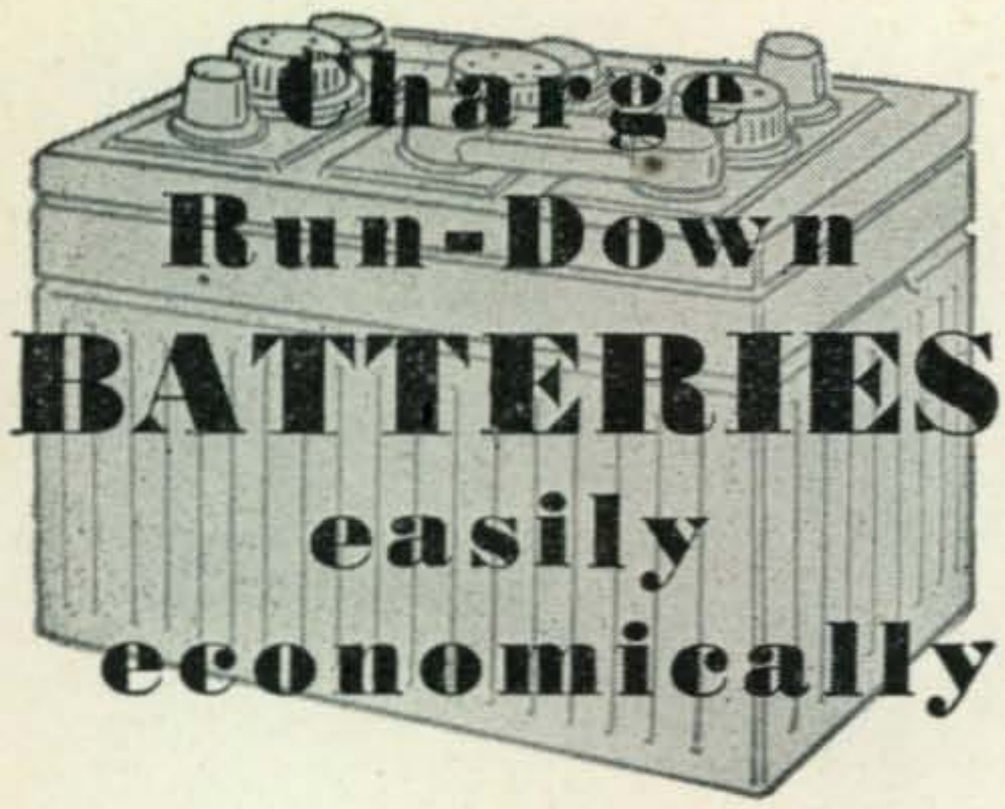

With a Mallory Portable Battery Charger it's a cinch to charge batteries in vehicles, laboratories or stations. Just plug the DC cord into the convenient dash receptacle and plug the AC cord into the nearest outlet—that's all there is to it!

TYPE 107

The jumbo job for quicker charging. Initial charging rate: 10 amperes tapering to 7 amperes as the battery builds up. Size: 9¼" high, 6¼" wide, 5¾" deep. Weight, only 11 pounds.

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Mallory's medium-sized charger, Type 5535 B, has an initial charging rate of 6 amperes, tapering to 4 as the battery builds up. Size: 7⅛" high, 4½" wide, 4¾" deep. Weight, only 7¼ pounds.

TYPE 3C

Mallory's Type 3C Battery Booster is the smallest of the family, with a charging rate of 4 amperes initial, tapering to 2 amperes. Size: 6" high, 3⅞" wide, 3⅜" deep. Weight: 4¾ pounds.

Mallory Battery Chargers are available from your authorized Mallory Distributor. See him for details about the complete Mallory line.

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CALLS LOGGED

STEPHENVILLE, NEWFOUNDLAND—W2IOP/VO

28 mc—Nov. 16th 1945

A3. W4AJI, W4GFE, W4GIY, W4HIL, W4NY, W4DWZ, W6ADV, W6QNC, W8STZ, W4GCA/9, W9ARI, W9OII, W9DIB, W9DDN, W9DJU, W9FBI/9, W9FCM, W9FIJ, W9GRV, W9HAQ, W9KFQ/9, W9LF, W9LKL/9, W9LKR, W9LTR, W9NKN, W9MRJ, W9OKR, W9QMN, W9SQH, W9VLS and W9WZO.

A1. VE4RO, W6BXL/6, W8SEY/8, W9LR/9 and W9MQT.

Nov. 17th 1945

A3. W4HIL, W4IDW/4, W5AAT, W5ESV, W6CHE, W6AOE, W6MBD, W6WN, W6PVD, W8EMD, W8BCJ/8, W8LFE, W8STZ, W8ROM/9, W9LF, W9IPO/9, W9EDR/9, W9AI/9, W9RLW, W9MRJ, W9CCW, W9LIR, W9RBI, W9KLC, W9LRI, W9OZZ, W9MHM, W9ESO/9, W9HWF, W9QUV, W9MVZ, W9VRP, W9KKT, W9BLL, W9FST, W9HAQ, W9CVU and W9IAW.

A1. W4BXP, W6ANM/4, W6NLI, W9AKQ, W9JNX, W6FMH, W7BYP and VE1EP.

Full details may be obtained by dropping a line to *CQ Magazine*, CALLS LOGGED dept.

— SHORTS —

Watch your 10-meter rig! Improperly adjusted, the 28-megacycle transmitter puts out a nice signal on 20 meters which is not yet open for amateur operation. Twenty-meter "QSL'S" have already been received from FCC monitoring stations! If there is no neighboring amateur to co-operate, move your receiver a few miles away for a check on doubler power getting through to the antenna.

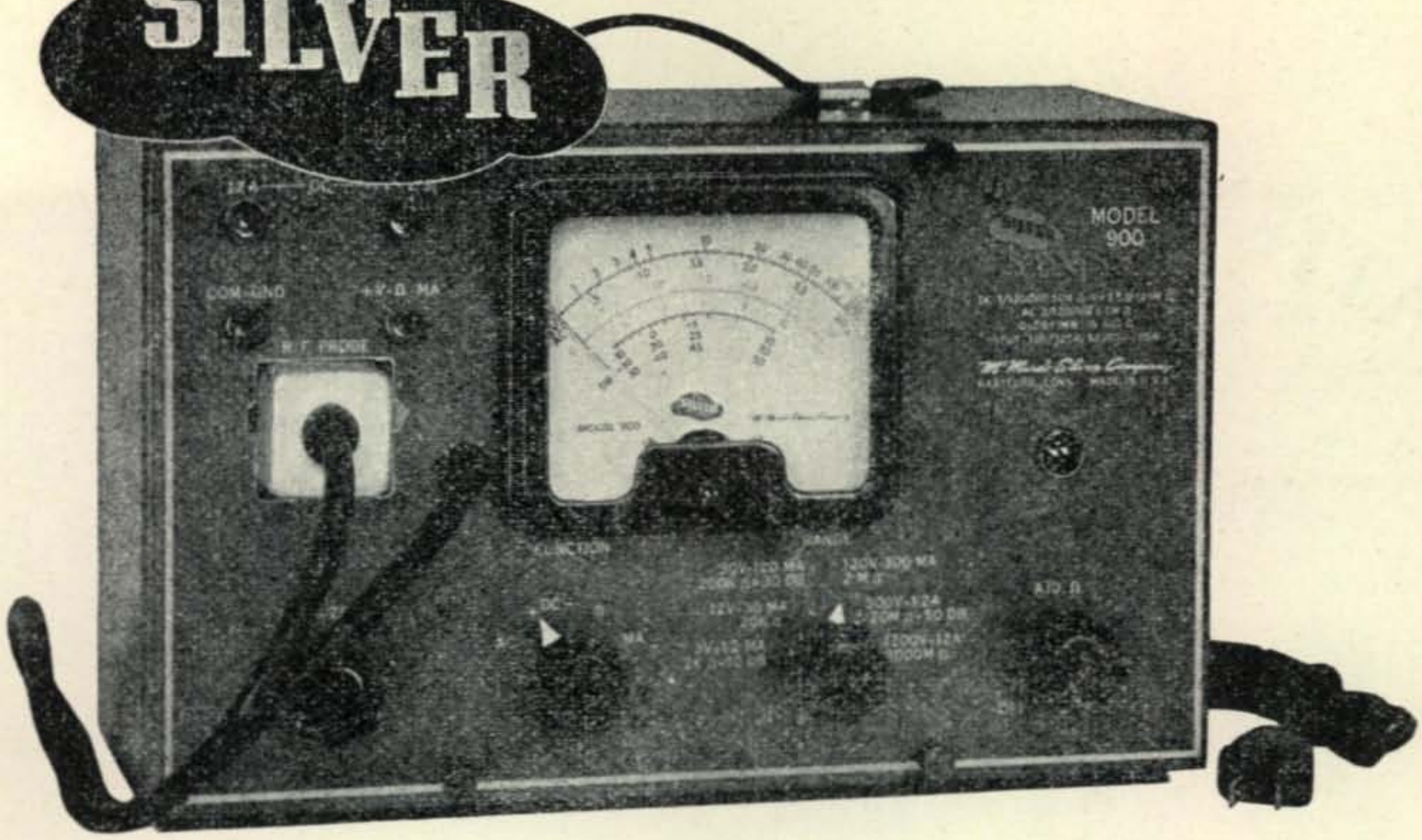
— . . . — . —

NEW "LIGHTHOUSE" TUBE

Eitel-McCullough, Inc., of San Bruno, California, announce the 3X100A11/2C39 transmitting tube. The tube is a miniature external anode triode, of the "lighthouse" variety, and offers exceptional performance in applications requiring up to 25 watts of power at frequencies to above 500 megacycles. Its rugged construction, unusually high transconductance and 100 watts of plate dissipation make it useful over a very wide range of frequencies, either in fixed or mobile equipment. It has an indirectly heated cathode with a 6.3 volt heater. The overall height is 2¾ inches and the diameter is 1¼ inches.—*CQ, Jan. 1946.*

— . . . — . —

SILVER



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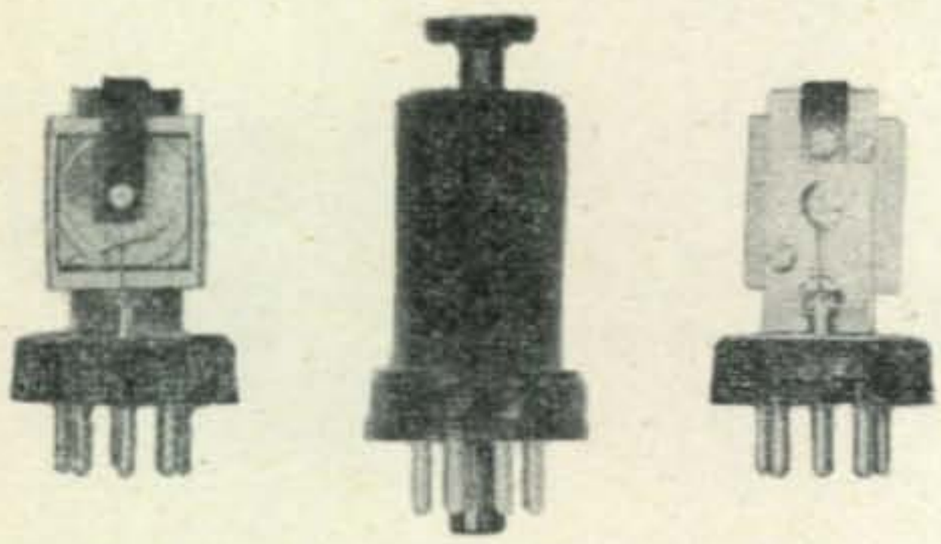

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—··· —·—

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vik, Alaska—a transmitter that is still perking! Celebrating a decade of service to the electronics industry, Electronic Mechanics has published several informative engineering bulletins showing the many uses in which Mykroy serves. Copies can be secured by writing to Electronic Mechanics, Inc., 2682 Clifton Blvd., Clifton, N. J.—*CQ, Jan. 1946.*

— · · · — · —

The FCC announced November 9th, 1945, several minor modifications in its proposed plan of frequency allocations, only one of which affects the amateur. The amateur band of 1145-1245 megacycles is shifted to 1215-1295 megacycles. We lose 20 megacycles.

– · · · –

The first post-war edition of the amateur call book is scheduled for publication with the "spring" copy, available about the first of March. The price will be $1.50. We're crossing our fingers for cross-indexing!

— · · · — · —

SOS for Literature

The Radio Club of New York is requesting radio magazines for European amateurs, engineers and technicians who have had no opportunity to read up on radio during the last five years and who are necessarily unaware of the advances made in this science. In these bundles for Europe, the NYC club particularly wants past numbers of CQ, QST, the HANDBOOK, RADIO, RADIO-CRAFT, RADIO NEWS and data published by tube and radio manufacturers. Arrangements are being made for distribution, and all publications should be forwarded to Post Office Box 48, Station C, New York 14, NY—or if you lend this copy of CQ and forget the QRA, just mail to CQ. We'll do the rest.

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Wanted

Club news and what gives at Hamfests. CQ holds its pages open each month for photos, personalities and dates of future get-togethers. RUSTY RIGS features photos and descriptions of old time shacks, but we still like to show our readers how the 1946+ versions are developing. READERS' LOG welcomes gripes as well as bouquets. As they say in the army (we're still technically at war), ZCF—we'll be seeing you.

HIGH OUTPUT

[*from page 30*]

oscillator, opens the lead to the receiver and connects a separate 4½-volt C battery for the microphone. In the receive position, the switch connects the loudspeaker, opens the lead to the transmitter, and inputs the detector to one of the primary windings of the transformer T_1. The 6C5-6F6 stages now act as a two-stage audio amplifier. In the receive position, the 50,000 ohm potentiometer provides a variable control of plate voltage on the 6C5 detector. Hiss level is held down to a minimum, and maximum sensitivity is thus realized.

The receiver employs a two-plate variable tuning capacitor, made by removing one stator plate from a three-plate midget. This small capacity provides better bandspread. The 6C5, tuning capacitor and coil are mounted on a vertical sub-panel made of bakelite or polystyrene, 2½" x 5" x 3/16", mounted on the chassis parallel to the front panel, (*Fig. 2*). The tuning capacitor must be insulated from the chassis and is tuned from the front panel with a ¼-inch diameter bakelite rod coupling it to the dial. The 6C5 should be mounted horizontally, as close to the capacitor and coil as possible. Radio-frequency circuits are wired with #14 solid copper wire.

The A-F End

The audio circuit offers no complications. The parts can be mounted in any convenient chassis location and this portion of the circuit is wired with ordinary hook-up wire. The ground leads often cause trouble on 144 megacycles and should

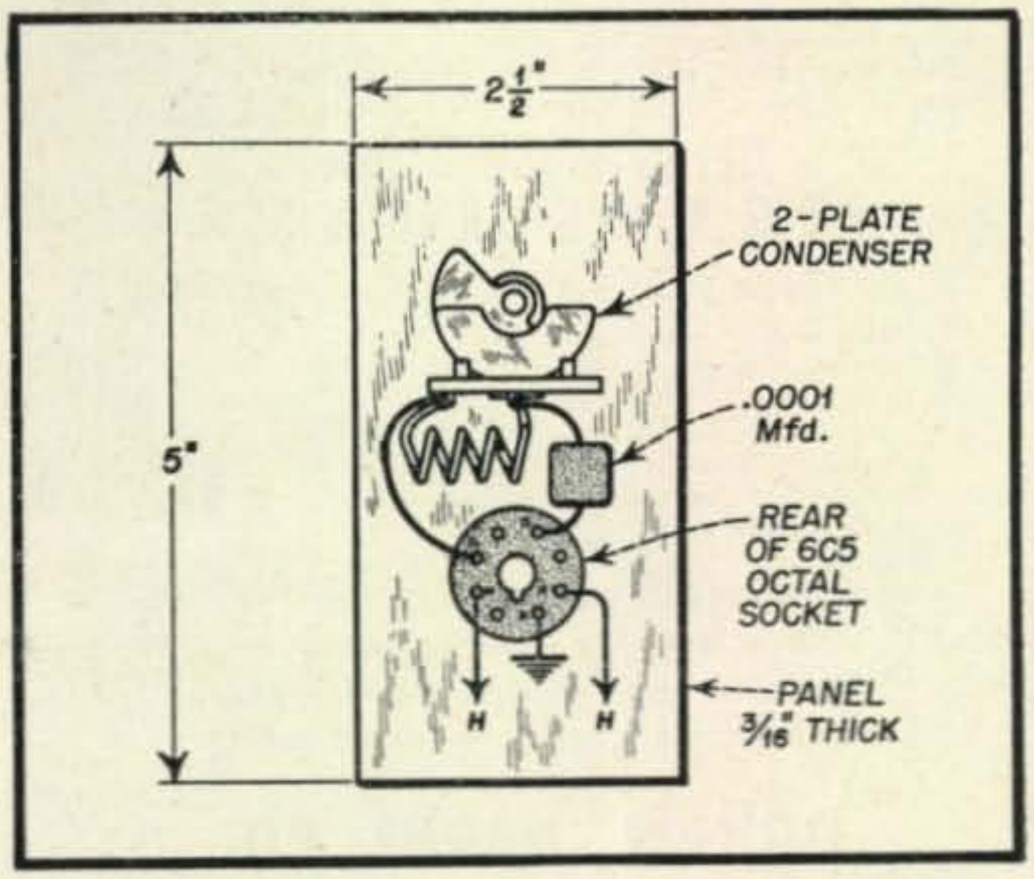

Fig. 2. Constructional detail—rear of detector panel

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be located with care, as the output may be increased by changing the length of these leads.

A 6.3-volt pilot lamp coupled with a 2-turn loop, ½-inch in diameter, made of insulated wire, serves as an r-f and modulation indicator. The lamp should increase in brilliancy when speaking into the microphone. The audio output is sufficient to operate a permanent magnet loudspeaker which is mounted behind a wire-screen grill on the side of the front panel.

The antenna coupling loops, L_2 and L_3, should be self-supporting and rigidly mounted. the r-f chokes, (*Fig. 3*) are wound with 50 turns of

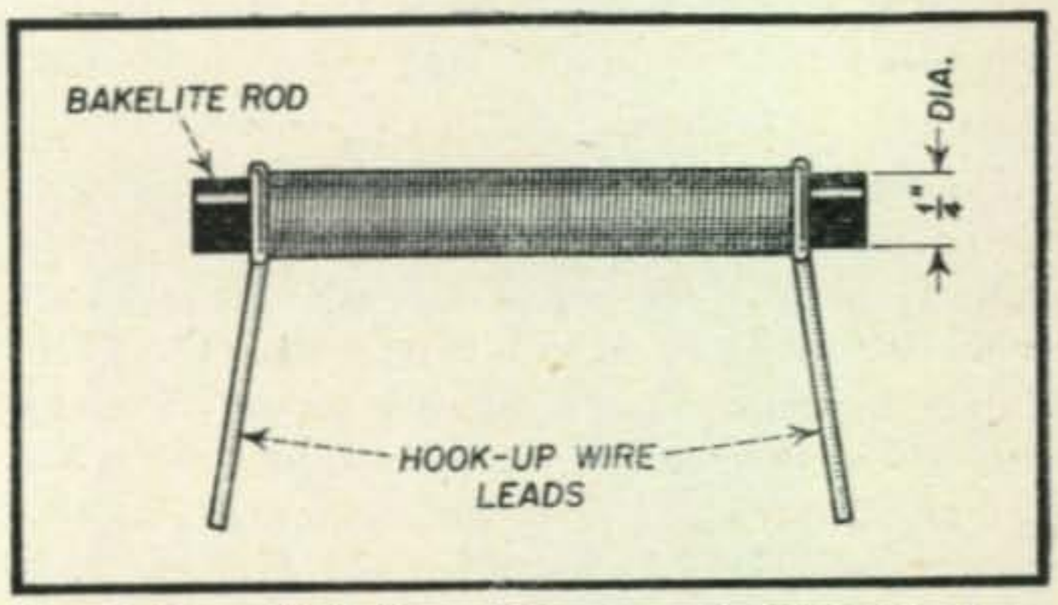

Fig. 3. The r-f chokes—50 turns of #34 DSC close-wound, single layer

#34 DSC wire on ¼-inch diameter bakelite or lucite rods. Holes are drilled through the rods at each end and a piece of bare hook-up wire inserted, bent over and soldered. The two ends of the radio-frequency winding should be soldered to these leads so that the chokes can be mounted solidly. Ohmite high-frequency r-f chokes, type Z-1, may be used instead of the home-made chokes if desired.

Operating Technique

In the transmit position, the 6L6 functions as an ultra-audion circuit and is modulated by the 6C5-6F6 stages, connected as a class A, constant current, Heising type modulator. The coil L_2, should be tightly coupled to the plate tank L_1, to provide maximum power transference to the antenna. On the other hand, L_3, is coupled just tightly enough to enable the detector to super-regenerate over the entire band. The shield of the 6C5 detector should not be connected to ground, but the rest of the tubes in the circuit have their shields grounded.

Antenna

The physical dimensions of the antenna offer an excellent opportunity for the construction of effective directive systems. The range at 144 megacycles is line-of-sight plus 10%, and a vertically polarized antenna results in better signal strength than one horizontally polarized. A vertically polarized antenna transmits a low

radiation angle wave parallel with the earth and the signal is broadcast equally in all directions from the antenna. At ultra-high frequencies, trees, hills and buildings will reflect or attenuate the transmitted wave often preventing reception at distant points when the obstructions lie between the transmitter and the receiving station.

Measurement of frequency in the 144-megacycle band may be determined by observing standing waves on a two-wire parallel transmission line or lecher wire system. At ultra-high frequencies, it is possible actually to measure the wavelengths generated as described in standard texts.

ON THE BEAM

[*from page 29*]

vious date with the same type radar, the radar operator is effectively guided by a form of pilotage, regardless of weather conditions. The PPI (Plan Position Indicator) is the most suitable cathode-ray tube presentation for airborne work, as most prominent ground features show up at their relative positions with respect to the heading of the plane in a fairly accurate projection. *Fig. 3* is a typical PPI 'scope photograph. Slant range from plane to ground "targets" is measured as the distance on the PPI from the center of tube to the echo representing each target. Concentric range circles are applied by circuits within the radar to facilitate slant range measurements. The most modern airborne PPIs automatically orient the presentation so that true north, rather than the plane's heading, is at the top of the 'scope with the plane's heading being shown as a line at the correct bearing measured from north. This more complex indication is most suited for bombing-through-overcast and entails the use of a more complex radar than is normally required for pilotage. While discussing the newest equipment, it may be mentioned that the most modern search apparatus is now simple enough in operation to allow the pilot himself to perform all necessary adjustments. For daytime use, the PPI is shielded from random light by a long visor; at night, with the 'scope brilliance kept at a low, the pilot may orient himself without experiencing impaired vision or "night blindness." In addition to being simple in operation, the newer equipments are lighter in weight one weighing slightly more than one hundred pounds complete with antenna.

Radar Beacons

In conjunction with ground radar beacons, or racons, the search set becomes even more of a distinct aid to navigation. Most airborne search

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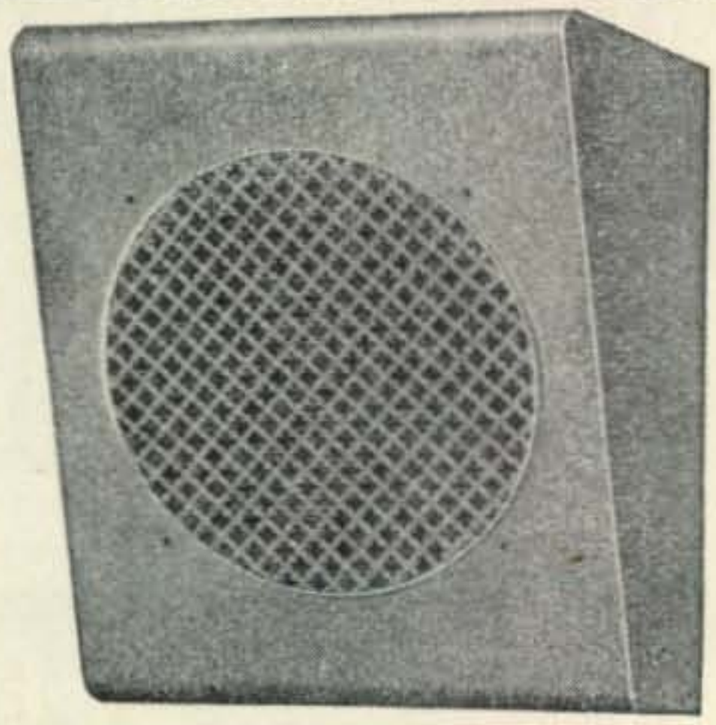

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sets are equipped for beacon operation by the throwing of a single switch. When on beacon operation, the r-f pulse width output of the airborne radar's transmitter is lengthened by several microseconds while the radar's receiver frequency is shifted into what is known as the "beacon band." Racons, now located at many airports, receive within radio range, all search pulses from airborne (and shipborne) radars in the vicinity. However they express interest in only those pulses (i.e. beacon pulses) that have been lengthened by several microseconds. Upon receipt of a beacon interrogation pulse of the correct length, the racon transmitter receives a triggering pulse from its receiver and immediately emits a series of pulses in the beacon band. In effect, the beacon interrogation pulse is detected, amplified and retransmitted almost instantaneously back to the radar by the action of the racon. Whereas some earlier racons replied to each interrogation pulse by one pulse in return, modern beacons reply to the query by transmitting a series of pulses (usually up to a maximum of five) in order to identify the particular racon being interrogated. Coding is accomplished by varying the number of reply pulses as well as the spacing between the pulses.

Because the start of the PPI sweep of the airborne radar coincides with the transmission of a burst of r-f energy, both for search and beacon operation, and since the racon repli to a beacon interrogation pulse with little or no internal time lag, the racon's output pulse arrives at the radar in the form of an amplified echo at an indicated PPI range equal to the slant distance between radar and racon. On beacon operation the detuning of the radar receiver from the radar transmitter's frequency impairs the normal search function, and hence only beacon pulses (from those racons within radio range) are visible on the PPI. These pulses however, will be displayed on the PPI at positions corresponding to the location of the various ground beacons with respect to the radar. *Fig. 4* shows the PPI of a radar on beacon operation with a racon reply at 30°—60 miles and another at 195°—92 miles. The top of the 'scope, or zero degrees, is the heading of the plane in this case.

Racons have a useful range of nearly 200 miles when aircraft are flying at considerable height, and they offer the radar operator a signpost of great value during those adverse moments when the terrain below, as viewed through the radar, is an unfamiliar mass of bright and dark patches. In conjunction with Loran, the beacon-equipped search radar tends to remove any doubts as to the location of a plane anywhere in space,—doubts that are usually in the mind of a pilot flying on luck and a prayer.

FLEXIBLE SHAFTING

[*from page 24*]

and staking, and rolling. (Special tools are required in most of these processes.)

A good craftsman could handle the first procedure, which consists of placing the fitting over the end of the casing and pressing together the common section between dies. A mandrel should be inserted in the bore of the casing to prevent distortion in the swaging operation.

Various adapters for flexible shafts are available. While most of them are designed for special applications, they can be used for similar purposes within their size range. Typical of these adapters are those designed for close clearance connections where space limitation does not permit a direct connection without bending the shaft too sharply. There is a T-type coupling which permits the branching of two shafts from one, and so on.

Direct coupling between the shafting and controlled unit is not always satisfactory because of torque. In these cases it is necessary to install a gear or gear-and-pinion arrangement. This can be a simple 1:1 ratio gear, or if vernier tuning is desired, a higher ratio of drive-to-driven.

The applications of flexible shafting in amateur radio are many-fold. Some possible uses are illustrated—but countless others will suggest themselves, such as remote control, coupling, unusual mechanical designs, rotary antenna indicators, and even turning small beams. Wartime surpluses and automobile fittings will supply sufficient quantities of shafting and accessories until such time as the special product is again available commercially.

KNOW YOUR METER

[*from page 19*]

microampere meter is used, it will permit a 0 to 1 megohm range with only 4.5 volts of battery.

Thermocouple Meters

It is not possible to use iron vane, rectifier or dynamometer instruments for the measurement of radio-frequency currents. One of the early types of r-f measuring devices was known as the "hot-wire" ammeter. This consisted of an alloy wire drawn taut between posts through which the radio-frequency current was passed. A thread was attached to the center of the wire, wound around the pointer shaft and thence to a tension spring. As r.f. flowed through the wire it became hot and thus expanded, permitting the tension spring to take up the slack, thereby pulling the

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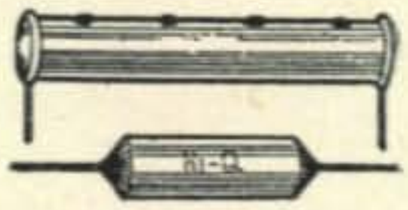

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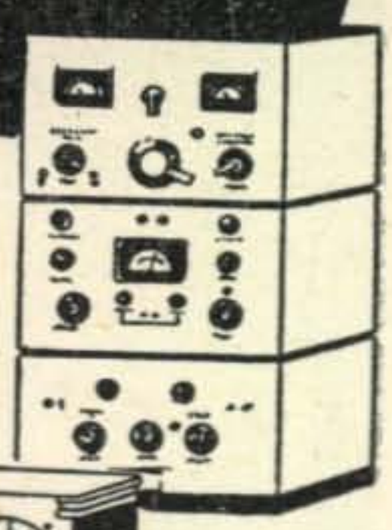

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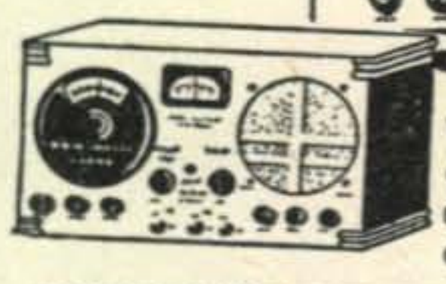

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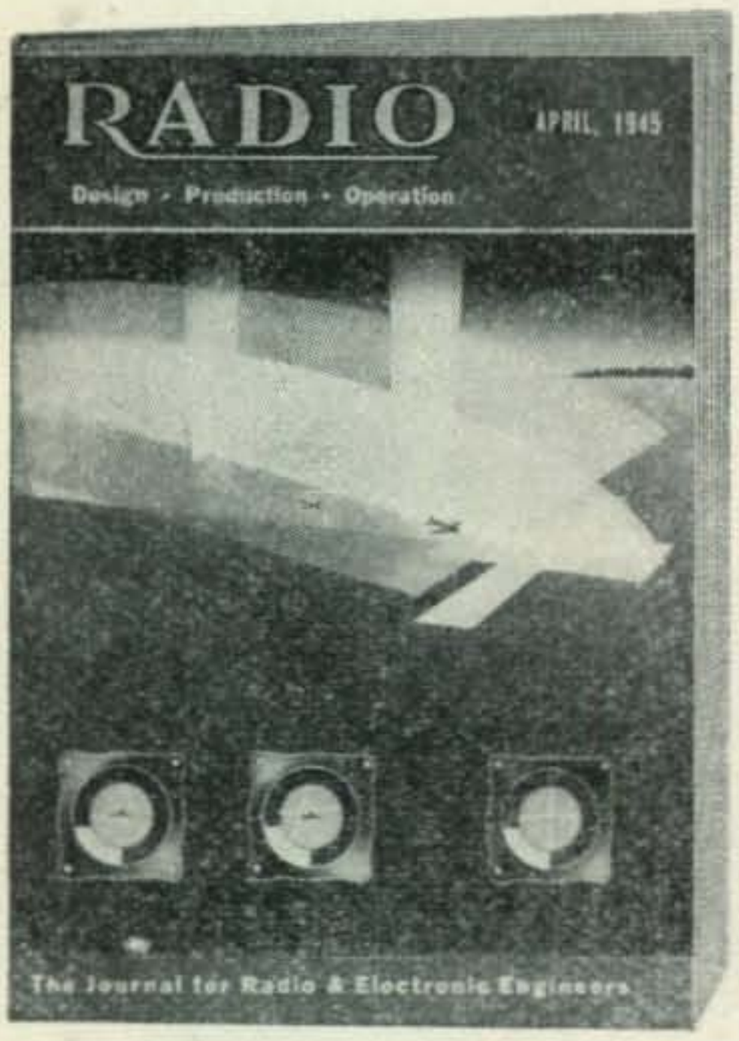

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thread which in turn revolved the pointer shaft causing the meter to indicate.

The modern and more efficient method of high-frequency current measurement uses the thermocouple. The principle of operation is based on the fact that if two dissimilar metals are joined and the juncture heated, a voltage will be developed across the metals, the value depending directly upon the temperature at the bond. If the two free ends are connected to a D'Arsonval meter, an indication will be obtained which may be calibrated in terms of the amount of heat in the couple which is directly related to the r-f current. Since the heat (power) is proportional to the current squared (I^2), the meter scale is not linear but is crowded at the lower end. The meter is therefore referred to as a current-squared meter.

A regular D'Arsonval movement is used but the internal resistance is kept as low as possible in order to transfer a maximum of power from the thermocouple to the meter. The thermocouple may be located in the meter or may be external so that it can be placed directly in the r-f circuit with the meter perhaps a long distance away.

Multi-Meter Circuits

Three basic multi-meter circuits that may be constructed from readily available parts, are shown in *Figs. 9, 10* and *11*. They are self-explanatory in that the ranges provided are listed with the parts list for each. Note that there are four parts lists. *Circuits C* and *D* having two parts lists due to different ranges for each. The constructor is thus given a choice of four multimeter arrangements. *Circuit B* features the shunt type ohmmeter outlined above. Four

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FIRST CHECK seventeen dollars takes INSTRUCTOGRAPH like new with book, fifteen tapes. Tempo Music Shop 5946, Hollywood Blvd., Hollywood 28.

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meter scales for these multi-meter circuits are illustrated in *Figs. 12, 13, 14* and *15*. These scales are available in various radio parts stores and are furnished for Weston, Triplett and Jewell three-inch meters.

HANDIE TALKIE

[*from page 11*]

because you do not know whether or not you have the correct harmonic. The signal generator is tuned to 18 megacycles, which is the 8th sub-harmonic of 144 mc. To verify this I checked with the 6th and 9th sub-harmonics and found the points on the 144-mc band to be the same. The signal generator calibration was slightly different from the Lecher wire measurements but the latter is close enough in most cases.

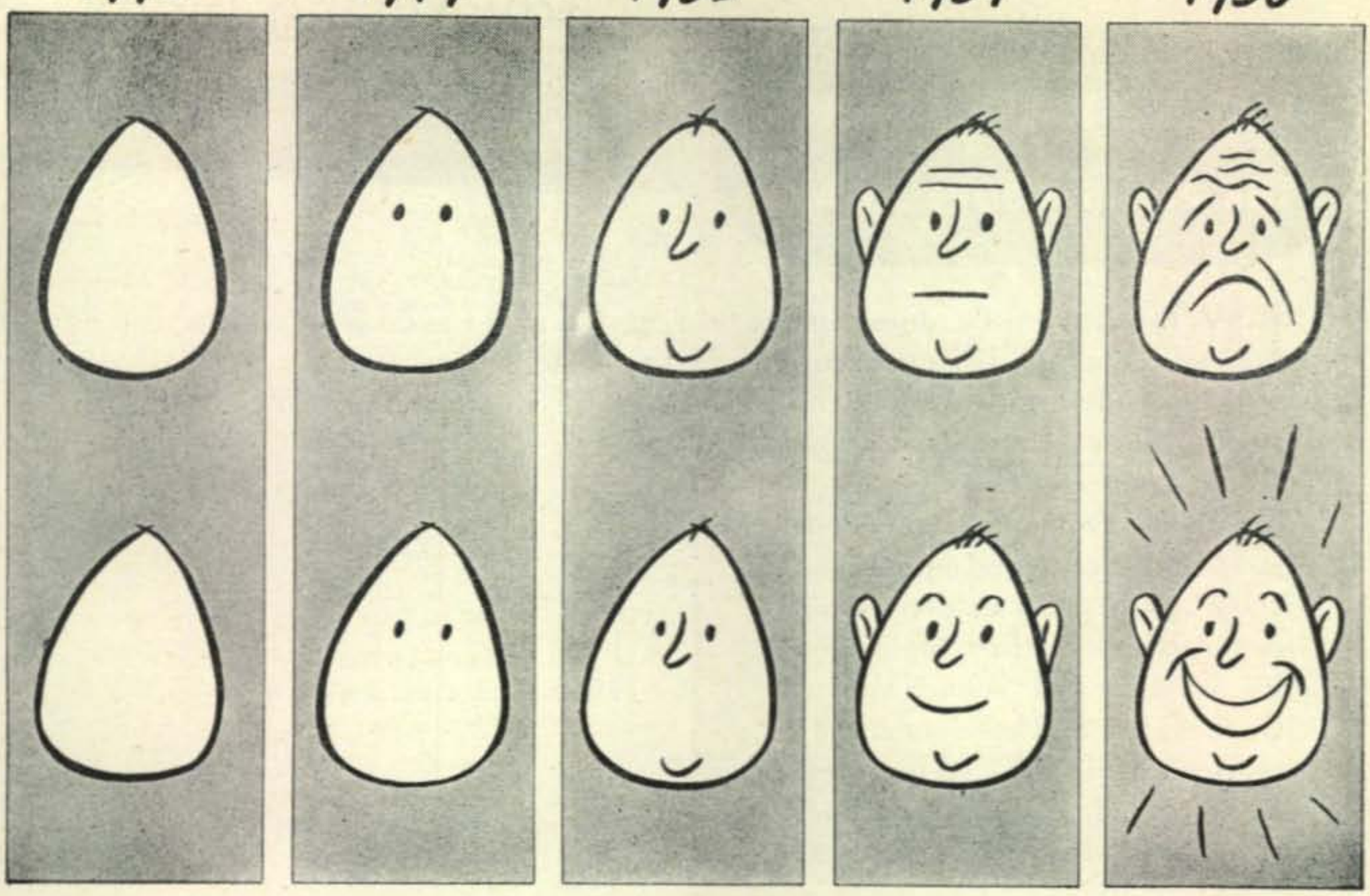
The antenna should be adjusted to a length which permits smooth regeneration over the entire dial. This will be found to be slightly above and slightly below the exact ¼ electrical wavelength at 146 megacycles. A 100,000-ohm optimum-valve resistor is substituted for the usual regeneration control in this Walkie Talkie.

The external battery connection is very convenient as it permits saving the small internal B battery when extended portable service is required. Ninety volts of external B battery works very well, providing more power and tends slightly to charge the internal B battery.

Conclusions

The writer has used this Handie Talkie without many of its present improvements, on 112 mc for over two years. Distances up to 6 miles have been easily covered over level ground, while the record is 35 miles from a high location in New Jersey to New York City. Of course if the QRM is very bad don't expect to communicate across these distances without considerable trouble. The power input to the oscillator is only .4 watt, but since there is ample modulation, reasonably good results can be expected.

From the photographs one can see that one's major effort will be expended in the construction of the cabinet and the other metal details. Without these parts closely duplicating those described in the text, the utility of the set may be greatly reduced. The wiring job on the average radio gear is rather simple as hard and fast rules apply to most wiring problems. However, in the construction of a portable radiotelephone which must be light in weight, compact, and dependable, the choice and layout of parts is a most important factor. The writer trusts this Handie Talkie will go a long way toward offering the amateur and the civilian what they are looking for in a high-frequency portable radio-telephone.



Two ways your face can grow in the next few years

USUALLY, our faces show what's happening to us.

For instance, suppose financial matters are constantly on your mind.

Suppose you know that there's practically no cash reserve between you and trouble.

It would be surprising if your face didn't show it.

But suppose that, on the contrary, you've managed to get yourself on a pretty sound financial basis.

Suppose that you're putting aside part of everything you earn . . . that those dollars you save are busy earning *extra* dollars for you . . . that you have a nest egg and an emergency fund.

Naturally, your face will show *that*, too.

There's a simple and pretty accurate way to tell which way your face is going to go in the next few years:

If you are buying, regularly, and holding as many U. S. Savings Bonds as you can, you needn't worry.

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Buy all the Bonds you can... keep all the Bonds you buy!

CQ MAGAZINE

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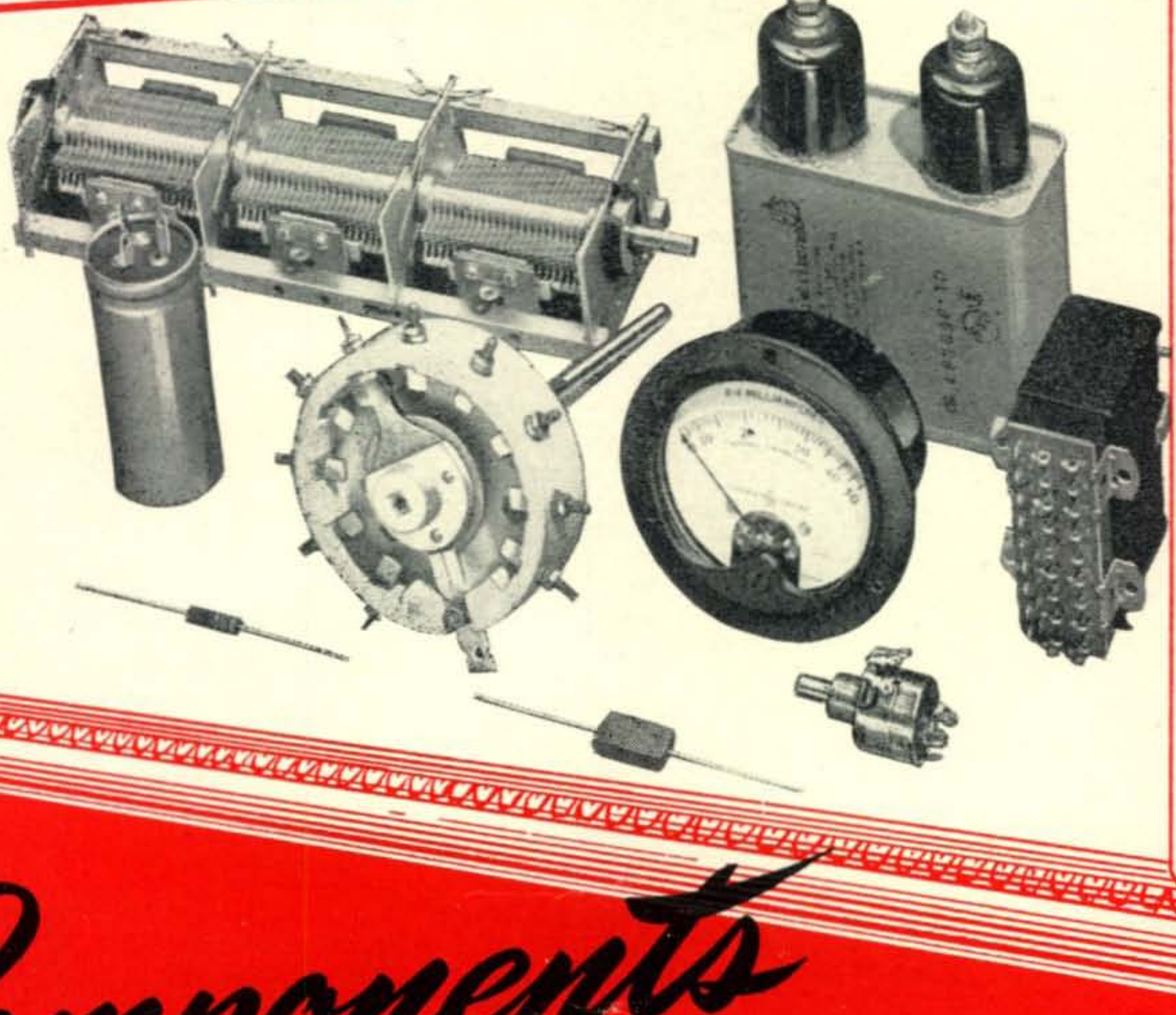

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